17

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INDEX SCIENCE CONSPECTUS VOL. II

PAGE

Abbot, C. G., The Radiation of the Sun..... 134
Aeroplane, The Modern, Earle L. Ovington.. 125
Anticipating Business Conditions, Roger Babson..... 148
Architectural Acoustics, Lecture by Prof. Wallace C. Sabine..... 87
Arizona, The Small Cave Houses of, H. W. Shimer..... 16
Artificial Respiration, Creating..... 90
Austin Dam, The, L. E. Moore..... 6

Babson, Roger, Anticipating Business Conditions..... 148
Berry, Charles W., Tesla's Rotary Machine.. 7
Brownian Movement, The, D. F. Comstock.. 69
Cave Houses of Arizona, The Small, H. W. Shimer..... 16
Cherries, Adulteration in Maraschino, E. B. Spear..... 124
Civilization in Egypt, The Dawn of, Lecture by Prof. Geo. A. Reisner..... 72
Comstock, D. F., The Principles of Relativity, 13, 40; The Brownian Movement..... 69
The Light Quantity Hypothesis..... 115
Conservation and Research, H. T. Kalmus.... 152
Darwin, A Dissenter from, Lecture by Prof W. Johanssen..... 38
Dreams," Hints from "The World of Percy G. Stiles..... 54
Dual Water Supply..... 90
Efficiency in Public Health Work, Selskar M. Gunn..... 58
Egypt, The Dawn of Civilizatiou in, Lecture by Prof. Geo. A. Reisner..... 72
Electrification, High Voltage, L. E. Moore.... 156
Electrification Problems, Solving, W. E. Wickenden..... 89
Emotion, The Physiology of, Percy G. Stiles.. 118
Food, Safeguarding Wholesome, A. G. Woodman..... 33
Food Preservatives, Spices as, Selskar M. Gunn 56
Fourth Dimension as a Text, E. B. Wilson.... 104
Gas, Poisoning by Illuminating, F. Schneider, Jr..... 122
Geology of the Rhine Valley, H. W. Shimer... 108

PAGE

Gigantic Engineering Undertaking, Fred F. Moore..... 93
Gunn, Selskar M., Isolating the Typhoid Bacillus, 52; Spices as Food Preservatives, 56; Efficiency in Public Health Work..... 58
Heredity as an Experimental Science, C.-E. A. Winslow..... 1
High Voltage Electrification, L. E. Moore.... 156
Hints from "The World of Dreams," Percy G. Stiles..... 54
"Holes in the Air," L. E. Moore..... 57
Johanssen, J. Prof., Lecture by, A Dissenter from Darwin..... 38
Kalmus, H. T., Conservation and Research... 152
Kuckenthal, Prof. W., Lecture by, Some New Facts About Whales..... 29
Light Quantity Hypothesis, The, D. E. Comstock..... 115
Liquid Crystals and Their Formation, Ellwood B. Spear..... 19
Lister, A Tribute to Lord, Lecture by Prof. Wm. T. Sedgwick..... 91
Loughlin, G. F., Potash Sources in the United States..... 45
Maraschino Cherries, Adulteration in, E. B. Spear..... 124
Mercury Vapor Lamp, Improving the, L. E. Moore..... 92
Milk Supply of Boston, The, Samuel C. Prescott..... 22
Modern Aeroplane, The, Earle L. Ovington.. 125
Monsters and Their Production, Charles R. Stockard..... 61
Moore, Fred F., A Gigantic Engineering Undertaking..... 93
Moore, L. E., The Austin Dam, 6; Storage Battery Electrification, 55; "Holes in the Air," 56; The Boston Subway, 78; Improving the Mercury Vapor Lamp, 92; A Remarkable Ore-Handling Dock, 120; High Voltage Electrification..... 156
New Members of the Society..... 39, 86, 121
Norton, John F., Ventilation of Sleeping Cars 79
Ore-Handling Dock, A Remarkable, L. E. Moore..... 120

505
.S415

PAGE

Ovington, Earle L., The Modern Aeroplane... 125
Ozone in Brewing, The Use of, F. Schneider, Jr. ... 147
Pasteur Institute, Science Fighting Against Disease ... 83
Physiology of Emotion, The, Percy G. Stiles .. 118
Potash Sources in the United States, G. F. Loughlin ... 45
Prescott, Samuel C., The Milk Supply of Boston ... 22
Principles of Relativity, The, D. F. Comstock 13, 40
Prolonging Life by Thorium, E. B. Spear ... 86
Public Health Work, Efficiency in, Selskar M. Gunn ... 58
Radiation of the Sun, The, C. G. Abbot ... 134
[illegible] Geo. A., Lecture, The Dawn of [illegible] ... 72
[illegible]
[illegible]
man ...
Schneider, F., Jr., Structural Strength of Plants, 92; Vegetables and Typhoid Fever, 119; Poisoning by Illuminating Gas, 123; Ringworm, 124; The Use of Ozone in Brewing ... 147
Science Fighting Against Disease ... 83
Sedgwick, William T., Lecture by; A Tribute to Lord Lister ... 91
Shimer, H. W., The Small Cave Houses of Arizona, 16; Geology of the Rhine Valley ... 108
Sleeping Cars, Ventilation of, John F. Norton 79

PAGE

Spear, Ellwood B., Liquid Crystals and Their Formation, 19; Prolonging Life by Thorium, 86; Adulteration in Maraschino Cherries... 124
Spices as Food Preservatives, Selskar M. Gunn 56
Stiles, Percy G., Hints from "The World of Dreams," 54; the Physiology of Emotion... 118
Stockard, Charles R., Monsters and Their Production ... 61
Storage Battery Electrification, Lewis E. Moore ... 55
Structural Strength of Plants, F. Schneider, Jr. ... 92
Subway, The Boston, L. E. Moore ... 78
Tesla's Rotary Machine, Charles W. Berry... 7
Thorium, Prolonging Life by, E. B Spear.... 86
Tribute to Lord Lister, a lecture. by W. T. Sedgwick ... 91
T[illegible]hoid Bacillus, Isolating the, Selskar M. [illegible] ... 52
[illegible]
[illegible]
Water Supply of New [illegible]
Whales, Some New Facts About, Lecture by Prof. W. Kuekenthal ... 29
Wickenden, W. E., Solving Electrification Problems ... 89
Wilson, E. B., The Fourth Dimension as a Text 104
Winslow, C.-E. A., Heredity as an Experimental Science ... 1
Woodman, A. G., Safeguarding Wholesome Food ... 33

INDEX SCIENCE CONSPECTUS VOL. II

PAGE

Abbot, C. G., The Radiation of the Sun..... 134
Aeroplane, The Modern, Earle L. Ovington.. 125
Anticipating Business Conditions, Roger Babson..... 148
Architectural Acoustics, Lecture by Prof. Wallace C. Sabine..... 87
Arizona, The Small Cave Houses of, H. W. Shimer..... 16
Artificial Respiration, Creating..... 90
Austin Dam, The, L. E. Moore..... 6

Babson, Roger, Anticipating Business Conditions..... 148
Berry, Charles W., Tesla's Rotary Machine.. 7
Brownian Movement, The, D. F. Comstock.. 69
Cave Houses of Arizona, The Small, H. W. Shimer..... 16
Cherries, Adulteration in Maraschino, E. B. Spear..... 124
Civilization in Egypt, The Dawn of, Lecture by Prof. Geo. A. Reisner..... 72
Comstock, D. F., The Principles of Relativity, 13, 40; The Brownian Movement..... 69
The Light Quantity Hypothesis..... 115
Conservation and Research, H. T. Kalmus.... 152
Darwin, A Dissenter from, Lecture by Prof W. Johanssen..... 38
Dreams," Hints from "The World of Percy G. Stiles..... 54
Dual Water Supply..... 90
Efficiency in Public Health Work, Selskar M. Gunn..... 58
Egypt, The Dawn of Civilization in, Lecture by Prof. Geo. A. Reisner..... 72
Electrification, High Voltage, L. E. Moore.... 156
Electrification Problems, Solving, W. E. Wickenden..... 89
Emotion, The Physiology of, Percy G. Stiles.. 118
Food, Safeguarding Wholesome, A. G. Woodman..... 33
Food Preservatives, Spices as, Selskar M. Gunn 56
Fourth Dimension as a Text, E. B. Wilson.... 104
Gas, Poisoning by Illuminating, F. Schneider, Jr..... 122
Geology of the Rhine Valley, H. W. Shimer... 108

PAGE

Gigantic Engineering Undertaking, Fred F. Moore..... 93
Gunn, Selskar M., Isolating the Typhoid Bacillus, 52; Spices as Food Preservatives, 56; Efficiency in Public Health Work..... 58
Heredity as an Experimental Science, C.-E. A. Winslow..... 1
High Voltage Electrification, L. E. Moore.... 156
Hints from "The World of Dreams," Percy G. Stiles..... 54
"Holes in the Air," L. E. Moore..... 57
Johanssen, J. Prof., Lecture by, A Dissenter from Darwin..... 38
Kalmus, H. T., Conservation and Research... 152
Kuekenthal, Prof. W., Lecture by, Some New Facts About Whales..... 29
Light Quantity Hypothesis, The, D. E. Comstock..... 115
Liquid Crystals and Their Formation, Ellwood B. Spear..... 19
Lister, A Tribute to Lord, Lecture by Prof. Wm. T. Sedgwick..... 91
Loughlin, G. F., Potash Sources in the United States..... 45
Maraschino Cherries, Adulteration in, E. B. Spear..... 124
Mercury Vapor Lamp, Improving the, L. E. Moore..... 92
Milk Supply of Boston, The, Samuel C. Prescott..... 22
Modern Aeroplane, The, Earle L. Ovington.. 125
Monsters and Their Production, Charles R. Stockard..... 61
Moore, Fred F., A Gigantic Engineering Undertaking..... 93
Moore, L. E., The Austin Dam, 6; Storage Battery Electrification, 55; "Holes in the Air," 56; The Boston Subway, 78; Improving the Mercury Vapor Lamp, 92; A Remarkable Ore-Handling Dock, 120; High Voltage Electrification..... 156
New Members of the Society.....39, 86, 121
Norton, John F., Ventilation of Sleeping Cars 79
Ore-Handling Dock, A Remarkable, L. E. Moore..... 120

PAGE

Ovington, Earle L., The Modern Aeroplane . . . 125
Ozone in Brewing, The Use of, F. Schneider, Jr. . . . 147
Pasteur Institute, Science Fighting Against Disease . . . 83
Physiology of Emotion, The, Percy G. Stiles . . 118
Potash Sources in the United States, G. F. Loughlin . . . 45
Prescott, Samuel C., The Milk Supply of Boston . . . 22
Principles of Relativity, The, D. F. Comstock 13, 40
Prolonging Life by Thorium, E. B. Spear . . . 86
Public Health Work, Efficiency in, Selskar M. Gunn . . . 58
Radiation of the Sun, The, C. G. Abbot . . . 134
Reisner, Prof. Geo. A., Lecture, The Dawn of Civilization in Egypt . . . 72
Relativity, The Principles of, D. F. Comstock 13, 40
Rhine Valley, Geology of The, H. W. Shimer 108
Sabine, Wallace C., Lecture, Architectural Acoustics . . . 87
Safeguarding Wholesome Food, A. G. Woodman . . . 33
Schneider, F., Jr., Structural Strength of Plants, 92; Vegetables and Typhoid Fever, 119; Poisoning by Illuminating Gas, 123; Ringworm, 124; The Use of Ozone in Brewing . . . 147
Science Fighting Against Disease . . . 83
Sedgwick, William T., Lecture by; A Tribute to Lord Lister . . . 91
Shimer, H. W., The Small Cave Houses of Arizona, 16; Geology of the Rhine Valley . . . 108
Sleeping Cars, Ventilation of, John F. Norton 79

PAGE

Spear, Ellwood B., Liquid Crystals and Their Formation, 19; Prolonging Life by Thorium, 86; Adulteration in Maraschino Cherries . . . 124
Spices as Food Preservatives, Selskar M. Gunn 56
Stiles, Percy G., Hints from "The World of Dreams," 54; the Physiology of Emotion . . . 118
Stockard, Charles R., Monsters and Their Production . . . 61
Storage Battery Electrification, Lewis E. Moore . . . 55
Structural Strength of Plants, F. Schneider, Jr. . . . 92
Subway, The Boston, L. E. Moore . . . 78
Tesla's Rotary Machine, Charles W. Berry . . . 7
Thorium, Prolonging Life by, E. B Spear . . . 86
Tribute to Lord Lister, a lecture. by W. T. Sedgwick . . . 91
Typhoid Bacillus, Isolating the, Selskar M. Gunn . . . 52
Typhoid Fever, Vegetables and, F. Schneider, Jr. . . . 119
Use of Ozone in Brewing, The, F. Schneider, Jr. . . . 147
Ventilation of Sleeping Cars, John F. Norton 79
Water Supply of New York, F. F. Moore . . . 93
Whales, Some New Facts About, Lecture by Prof. W. Kuekenthal . . . 29
Wickenden, W. E., Solving Electrification Problems . . . 89
Wilson, E. B., The Fourth Dimension as a Text 104
Winslow, C.-E. A., Heredity as an Experimental Science . . . 1
Woodman, A. G., Safeguarding Wholesome Food . . . 33

SCIENCE CONSPECTUS

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HEREDITY AS AN EXPERIMENTAL SCIENCE

HISTORY OF THE MODERN STUDY OF INHERITANCE—FUNDAMENTAL FACTS UNDERLYING MENDELIAN HEREDITY—DEVELOPMENT DETERMINED BY CHEMICAL COMPOSITION

BY C.-E. A. WINSLOW

Smithsonian Institution JUL 22 1915 Astrophysical Observatory

PROFESSOR H. H. TURNER, in his presidential address before the Mathematical and Physical Section of the British Association for the Advancement of Science, last summer, sounded a protest against the assumption that experimental science is the only kind worthy of serious attention. Great advances have been made toward theories of fundamental importance by observation and statistical analysis. In many fields, where experiments cannot be made, these methods offer our only hope of advance toward the occupation and control of the unknown. The Darwins who follow such paths are as worthy of honor as the Pasteurs who pursue the road of experimentation. Yet a new and powerful instrument of research has been acquired, whenever any branch of science is brought within the field of experiment. There is, perhaps, no tendency more striking in recent biology than the spread of the experimental method, and in the study of heredity, in particular, its use has been attended with achievements of the first importance.

The history of the modern experimental study of inheritance is bound up with the discovery of a single observer, whose work, neglected at the time, now appears of such fundamental importance, that the whole method of study is called by his name. Gregor Johann Mendel was an Augustinian monk in a monastery at Brünn. His work was mainly teaching in the Realschule, which was then a function of the monastic order, but he divided his energies between the school and the garden of the monastery. Here he experimented on plant breeding, crossing different races of sweet peas, and other forms, and observing the behavior of the hybrids in their subsequent generations with inexhaustible patience and care. In 1865 he reported his results on sweet peas before the Natural History Society of Brünn, and between 1866 and 1873 he described them in a series of letters to the famous botanist, Carl Nägeli. Nägeli was courteous and helpful, but altogether failed to grasp the importance of Mendel's results, and, although the publications of the Brünn society found their way into most of the academies of Europe, no one seems to have noted the work of the obscure Bavarian monastic. Mendel is known to have felt this neglect, as well he might, and is reported to have

consoled himself with the thought "*Meine Zeit wird schon kommen.*" But it came too late. In 1868 he was chosen abbot of the monastery, and in 1872 became involved in a prolonged controversy with the Government, and his researches ceased. He died, unknown to science, in 1884. It was only in 1900 that three different observers, De Vries, Correns and Tschermak, rediscovered the same phenomena, confirming and extending his observations; and the biological world has echoed with Mendel and Mendelism ever since.

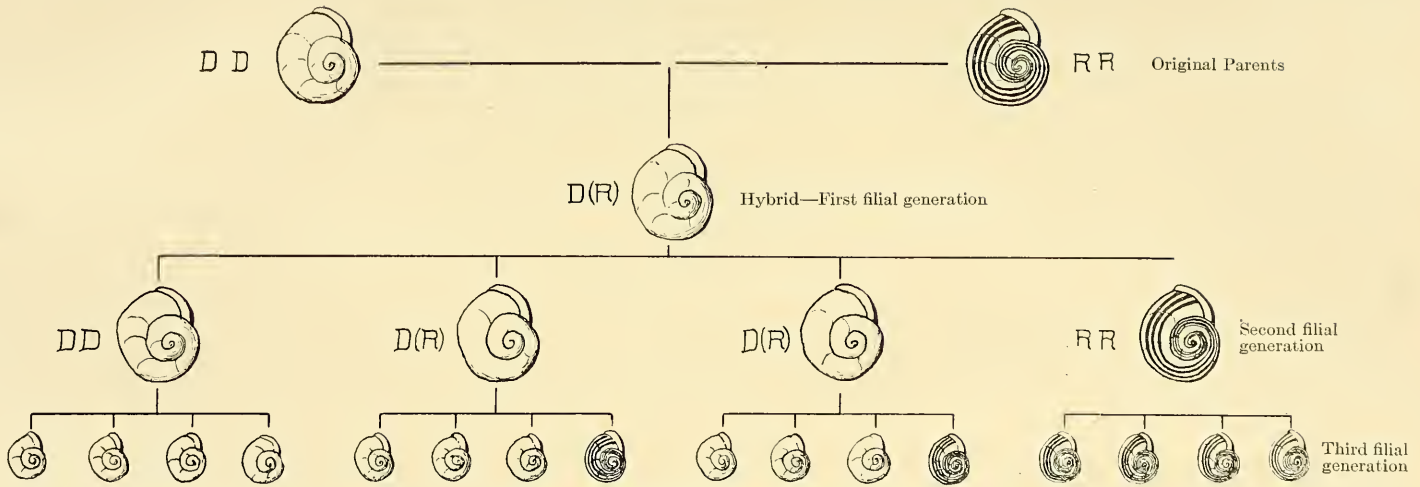
The fundamental facts, underlying what is known as Mendelian heredity, may be best understood by considering one of Mendel's own striking experiments. He crossed a dwarf pea with a tall race. The offspring in the first generation were never intermediate in character but all like the tall parent. When these tall peas of the first filial generation were bred by self-fertilization a very curious but regular phenomenon was manifest. Out of every four individuals in the second filial generation, three were tall and one short. The short individuals all bred true to shortness when self-fertilized. One of each three tall peas bred true to tallness, when self-fertilized, and the other two out of each three tall plants in this second generation behaved like the tall hybrids of the first filial generation, producing in their offspring one pure short plant, one pure tall plant and two tall plants, which showed on still further breeding the power of producing both tall and short individuals.

From this, and from innumerable experiments which have been conducted since Mendel's day, on the colors of animals and plants, on the shapes of flowers and seeds, and leaves, the habit and hairiness of plants, the susceptibility of wheat to rust disease, the presence of horns in certain breeds of cattle, the hair characters of guinea pigs, and rabbits, the waltzing habit in mice, the combs and other structures of fowls and canaries and pigeons, the markings of snails and many other characters,—three general principles of Mendelian heredity have been derived, which are expressed in the conceptions of unit factors, dominance and segregation.

The most fundamental of these conceptions, and the one of widest general import, is that of unit factors, factors present in the germ plasm which determine the presence of a certain character in the adult. There is a definite factor, doubtless a chemical substance, which determines tallness, or wrinkled seeds, or a long hairy coat, or immunity against rust. The opposite condition may be caused, merely by the absence of the first factor, or by the presence of another which operates in the contrary sense. It is most convenient in a general discussion to assume two different substances, a shortness-producing compound and a tallness-producing one.

In a hybrid which contains each of the two opposite factors, tending to determine respectively the presence and absence of a character, there is usually no blending. The offspring are all of one kind; as in Mendel's tall peas of the first filial generation. The factor which prevails when both are present is called dominant, and the one which does not, recessive. Tallness in peas is dominant, dwarfness recessive.

The explanation of the observed phenomena in experimental breeding rests on the third fundamental conception, that of segregation. When a pure bred tall pea is crossed with a pure bred dwarf the offspring in the first filial generation will all contain the tall factor, derived from one parent, and the short factor derived from the other. They will all appear tall since tallness is dominant, but they will all be hybrid in composition having within them the potency of tallness from one parent and the potency of shortness from the other. When the germ cells of this first filial generation are formed, however, the two antagonistic factors separate or segregate, so that among both the female cells and the male or pollen cells half contain only the tall factor, and half, only the short factor. Self-fertilization is accomplished by picking out the pollen and applying it to the stigma of the female organ. Under these conditions it will be obvious that on the



Mendelian Inheritance in Snails; Plain and Banded Shell (Lang)
(Diagram by J. H. O'Neill, M. I. T. '10)

The illustration shows the progeny, according to observation, of an unbanded snail which has the dominant character only and a banded one which has the banded or recessive character only, these being indicated by DD and RR respectively. The first hybrids will all of them have both characters with unbandedness only appearing, as the D character is dominant over the R. Mating two individuals of this generation, the D character will meet the D character in one-fourth of the second generation, making a pure strain dominant individual; in half the cases it will meet an R character in which the R will be dormant, the individual resembling in color its dominant grand parent, while in one-fourth the R character will meet the R character and in their union make an R individual. The average number of individuals of each kind is shown as three unbanded to one banded. Now if these second generation animals be mated, the result mathematically is shown in the third generation, ten unbanded to six banded.

doctrine of chances, an average set of four individuals of the next (or second filial) generation will include the following four combinations:

1. Tall male x tall female.
2. Tall male x dwarf female
3. Dwarf male x tall female
4. Dwarf male x dwarf female.

The plants which develop from the first three crosses will all be tall. The first will have only the tall factor in it, and when self-fertilized, will always breed true; the fourth has only dwarfness in it, and will always breed true with respect to tallness and shortness. The second and third will be hybrids like the original first filial generation, and their offspring, after self-fertilization or intercrossing with each other, will repeat the proportion of one pure dominant, one pure recessive and two plants, showing the dominant character, but hybrid in composition.

The case here discussed is a very simple one. When several different characters are concerned, the Mendelian formula becomes more complex. Where two separate variables, like color and flower shape, are concerned, nine individuals, out of sixteen in the second filial generation, show both dominant characters, three show each dominant character combined with the other recessive character and one only shows both recessive characters. Where four separate factors are inherited, an individual, showing pure recessive characters in all of them, will appear only once among 256 offspring. Furthermore, the course of events is complicated in many cases by the fact that two or more separate characters are coupled together, so that one carries the other with it in inheritance. The first case of this kind to be carefully studied was a cross between sweet peas differing in color and in the shape of the pollen. Flowers of either purple or red, produced from this cross, should have shown three examples of (dominant) long pollen to one (recessive) round pollen, but, as a matter of fact, there appear twelve times as many longs as rounds among plants with purple flowers, and three times as many rounds as longs among plants with red flowers. Roundness of seed and redness of flower are associated, as if, in the segregation when sex cells are formed, their unit factors tended to be bound together. Cases of this kind can often be explained on simple assumptions in regard to the coupling of the unit factors, and, when these assumptions are made the results of certain elaborate breeding experiments may be predicted with a high degree of accuracy.

One of the most general phenomena, which appears to fall in the same category with Mendelian heredity, is that of differences in sex. The fact that in every species of the higher plants and animals two different forms of offspring are produced, in approximately equal numbers, offers a problem, whose mystery is only forgotten because of its familiarity. Innumerable attempts have been made to explain this fact, and even to control the production of one sex or the other, but without avail. On the Mendelian assumption that one sex contains only recessive unit factors for sex, while the other contains dominant factors also, the phenomena can be explained with ease. Thus, in the canary, it appears that the female carries a male factor and a female factor, with femaleness dominant while the male has only male factors. When the factors segregate in the formation of the sex cells, all the male sex cells will contain the male factor, while half the female sex cells will contain the male factor and half the female factor. When the sex cells unite, the result will be the production of the two sexes in equal proportions, the males being pure recessives, the females of hybrid nature.

If the male contributes x and x, the female x and y, half the offspring will be x x (male) and half x y (female).

These phenomena can only be assumed, not actually proven, in ordinary cases. In a number of instances, however, it happens that certain obvious characters, like color, are coupled with the sex factors,—there is sex-limited inheritance,—and here it is possible, by observing the character coupled with sex, to study the behavior of the sex factor itself. The results of such experiments tend to con-

firm the assumption that sex behaves as a Mendelian character; and they are in general harmony with the brilliant researches of Professor E. B. Wilson, discussed in SCIENCE CONSPECTUS a year ago, which have shown that, in many forms, the cells which are to produce males and females are distinguished by the presence or absence of a visible morphological structure, the sex,—or accessory,—chromosome.

Professor Johannsen, the distinguished Danish biologist, now visiting the United States, has emphasized the underlying lesson of such experimental work as that of the Mendelian breeders by coining two terms, Phenotype and Genotype. A phenotype is a particular kind of organism, showing certain characters whether as a result of heredity or environment. A genotype is a definite kind of germ plasm, such as is obtained by self-fertilization of sex cells from a pure bred organism. Whatever characters may be temporarily displayed as a result of environment only pure characters will be handed on to future generations by a pure genotype. Different genotypes may produce the same phenotype. Thus a Mendelian hybrid and a pure dominant look alike, but breeding experiments show their genotypical difference. Of course the conception of hereditary and environmental factors in the life of organisms is an obvious and an ancient one; but it has acquired a new precision and definiteness as a result of Mendelian study. Furthermore, Professor Johannsen has shown that pure genotypes are very stable in their qualities. If selection operates on an ordinary mixed population, such as we find in a field of bean plants for example, the average characters may be changed appreciably. If, however, the offspring of a single pure line be obtained by self-fertilization, selection from among the varying phenotypes which arise produces no effect on the race as a whole, each generation reverting to the same average characters. The same thing has been shown in the Institute of Technology laboratories in regard to bacteria. Selection under normal condition is selection among a mixed lot of genotypes. It does not affect the underlying characters of the genotype itself.

It must not be thought that Mendelian heredity is universal, or that even where it occurs it is always susceptible of easy explanation, Many puzzling and complicated results have been obtained, which cannot yet be harmonized with any simple Mendelian formulas. In the inheritance of many characters, Mendelian segregation does not appear to play any part at all. The characters of the parents blend, as in the inheritance of skin color in man. Such phenomena may, perhaps, be due to the fact that the character in question is a product of a number of independent Mendelian factors but this is at present a pure assumption. In many instances of human heredity the Mendelian formulæ are, however, clearly evident. The absence of pigment factors in the iris of the eye is recessive to the presence of pigment. Thus, blue-eyed individuals are pure recessives for this character and have only blue-eyed offspring. Certain pathological conditions, like that in which the fingers lack one joint, and like congenital cataract, are simple Mendelian dominants. Night blindness, the condition in which the individual cannot see in a dull light, has been traced in this way through nine generations going, back to the seventeenth century.

The importance of these researches in their bearing upon human life is not negatived by the fact that strict Mendelian heredity has only been demonstrated in the case of a few simple characters, like those just mentioned. The main point is that certain hereditary characters of plants, and animals, and man, have been shown by experiment to be transmitted in accordance with simple laws so as to give predicable results. The facts point clearly in these cases to the presence of definite unit factors, chemical substances, or complexes of substances which act as determinants of the characters of the adult. Whether the problem can be worked out in all cases by the same formulæ, or by any simple formulæ, is a minor question. It has been worked out in a sufficient number of cases to furnish

strong support for the conception that inheritance consists in the transmission of specific chemical substances, and for the conclusion that this chemical basis is of supreme importance in determining the development of the organism in after life. As Professor Bateson said in his inaugural address at Cambridge University, "We have long known that it was believed by some that our powers and conduct were dependent on our physical composition, and that other schools have maintained that nurture not nature, to use Galton's antithesis, had a preponderating influence on our careers, but so soon as it becomes common knowledge—not a philosophical speculation, but a certainty —that liability to a disease or the power of resisting its attack, addiction to a particular vice, or to superstition, is due to the presence or absence of a specific ingredient; and finally that these characteristics are transmitted to the offspring according to definite predicable rules, then man's views of his own nature, his conceptions of justice, in short, his whole outlook on the world, must be profoundly changed."

THE AUSTIN DAM

The query that naturally comes to the non-professional reader after the failure of a dam or large engineering structure is, "Can engineers determine with accuracy how to build such structures so that they will do the legitimate work for which they are intended without failure?"

It will be reassuring to the public to know that it is entirely possible to build such structures so that they will do their duty without failure. In building a dam, the fundamental thing for the engineer to know is the character and condition of the underlying strata, in order that he may be certain it will carry the load that is proposed to be put upon it; if there is any possibility of water percolating through it, beneath the dam; and especially to find whether or not there is a geological fault on the proposed site. It is obvious that an exact knowledge of the condition of the foundation is absolutely necessary. A competent engineer will take measures to find out the facts and these being known, an absolutely safe dam can be built.

In the last ten years two so-called Austin Dams have failed, one located at Austin, Texas, and the last one at Austin, Pa. The failure of the Austin, Texas, dam was due primarily to its location upon a known geological fault. This dam slid carrying a portion of the rock underneath it with it. Had it been built beyond the location of the fault it would have stood probably without any question.

The failure of the Austin, Pa., dam was due primarily to the percolation of water underneath the dam. It was badly designed and poorly constructed. Its failure was also primarily due to its sliding, carrying certain portions of the rock foundation with it. One report states that there was not sufficient bond or adhesion between the different courses of the concrete. In explanation of this, we will say that after a course of concrete has been placed and leveled off and allowed to remain until the next day, a milky substance called "laitance" rises to the top of the concrete while it is setting. This substance has little strength and is useless as a bonding material. It must be thoroughly cleaned off before another course of concrete is placed. There is some evidence that this was not done in the case in question.

The underlying cause of failure seems to be undue economy in the engineering. Failures similar to this one are often due to a mistaken idea of economy in the engineering work, skimping of material and lack of competent inspection. Money spent in securing the services of a competent engineer is always a good investment.

L. E. M.

FUEL FOR THE FUTURE

Mr. Joseph A. Holmes, director of the United States Bureau of Mines, states that the deposits of lignite in the United States cover 116,700 square miles of which 53,000 square miles are in Texas and 31,000 square miles in North Dakota. Investigation shows that this lignite is suitable for manufacture of briquettes on a commercial scale for fuel purposes.

TESLA'S ROTARY MACHINE

IF THE THERMAL EFFICIENCY OF THIS ENGINE IS AS CLAIMED, THE PRIME-MOVERS OF THE WORLD WILL BE CONSIGNED TO THE SCRAP-HEAP

BY CHARLES W. BERRY

An ideal engine would involve both thermal and mechanical perfection.

Thermal perfection would insure the elimination of heat conduction losses so that that portion of the heat energy theoretically available for work might be utilized. Mechanical perfection would involve simplicity of construction, certainty of action, reversibility, uniform rotative effect, small cost of construction and no depreciation. The present important types of prime movers—reciprocating engines and turbines—meet these requirements unsatisfactorily. In thermal efficiency they are nearly equal, what the one loses in heating and cooling the cylinder walls the other dissipates in nozzle friction, and from imperfect utilization of the energy of the jet. Mechanically the turbine for certain loads seems to possess an advantage because of its more constant rotative effect, but its complexity vastly exceeds that of the reciprocating type. The large units of both types are very complicated in construction and there seems to be no possibility of making any radical simplification.

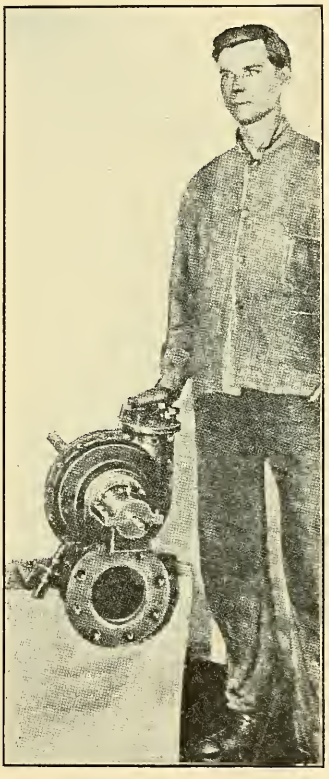


Fig. 1. Size of the Tesla Turbine. A 110 horse-power machine in the hand of the man who runs it

Innumerable efforts have been made to perfect a rotary engine which should combine the relative simplicity of the piston type with the constant rotative effect of the turbine, but unfortunately these accentuate the heat losses due to heating and cooling of the cylinder walls, so that their thermal efficiency has not, at least up to the present, been satisfactory.

It was thought by many that the last word had been said in engine design—that from now on improvements would consist merely in perfection of detail. But now without any preliminary notification Tesla has given a new type of motor to the engineering world for which he is making great claims. He states: *"Here is a simple structure, a casing with two entrances, disks arranged on the shaft and outlets in the center for the escape. In this instance the power is applied to one of the openings and the fluid moves with decreasing velocity toward the center until its energy is exhausted and transferred to the shaft. If the theory is correct I am able to take out the entire energy of steam in one single stage. In the present turbine, sixty-five per cent is the limit of efficiency; theoretically I should be able to get ninety-nine per cent of the total energy of the steam on the shaft in these turbines. A machine will develop ten

** Electrical Review and Western Electrician*, May 20, 1911, p. 988.

horse-power for every pound of weight. This principle can also be applied to the gas turbine. . . . We have a prime mover which is reversible, ideally simple, of enormous torque, incomparably greater than the turbine possesses."

This prophecy unless substantiated to a certain extent by actual accomplishment could hardly hope to hold public attention, but later publications have shown that turbines of this construction are in actual operation and apparently obtaining creditable results.

There are two turbines installed at the Edison Waterside Station, New York. Each of these develops 200 horse-power in a single stage with atmospheric exhaust when running at 9,000 revolutions per minute under a boiler pressure of 125 pounds. Each turbine, which weighs less than two pounds per horse-power, is contained within a space measuring 2 feet by 3 feet by 2 feet in height. The consumption under these conditions of maximum output is thirty-eight pounds of saturated steam per horse-power per hour.† One may be permitted to wonder just how the steam consumption was measured, as the large condensers of the Edison Station are scarcely adaptable to such small units, but the fact that such figures are quoted brings this motor within the reach of engineering possibilities. The engineering world will await with considerable interest the publication of any further information until Mr. Tesla is willing to impart it.

The compactness,* general appearance,** and internal construction*** of the turbine are shown in figures 1, 2 and 3. The rotor consists of twenty-five flat disks, one thirty-second of an inch in thickness, of hardened and carefully tempered steel. The face of the rotor is 3½ inches wide and its diameter 18 inches. The rotor is mounted in a casing which is provided with two inlet nozzles; one for use in direct running, the other for reversing, the reversal being effected by simply turning a valve. Openings are cut out at the central portions of the disks and these communicate directly with exhaust ports formed in the side of the casing. Mr. Tesla sums up the mechanical advantages of his engine as follows: ††"It is simple, light, and compact, subject to but little wear, cheap, and exceptionally easy to manufacture, as small clearances and accurate milling work are not essential to good performance. In operation it is reliable, there being no valves, sliding contacts, or troublesome vanes. It is almost free of windage, largely independent of nozzle efficiency,

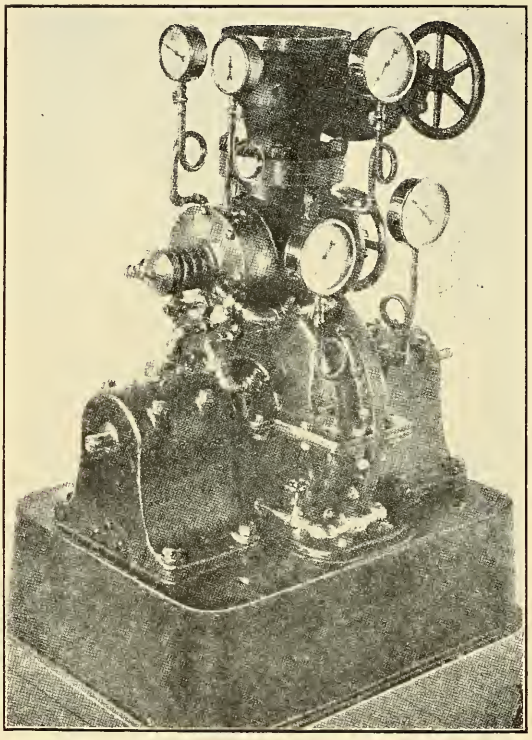


Fig. 2. A 200 horse-power Tesla Steam Turbine

† *Scientific American*, September 30, 1911, p. 297.
* *The Literary Digest*, October 28, 1911, p 733, 2d col.
** *Ibid*, p. 732; *** p. 733, 1st col.
†† *Electrical Review and Western Electrician*, September 9, 1911.

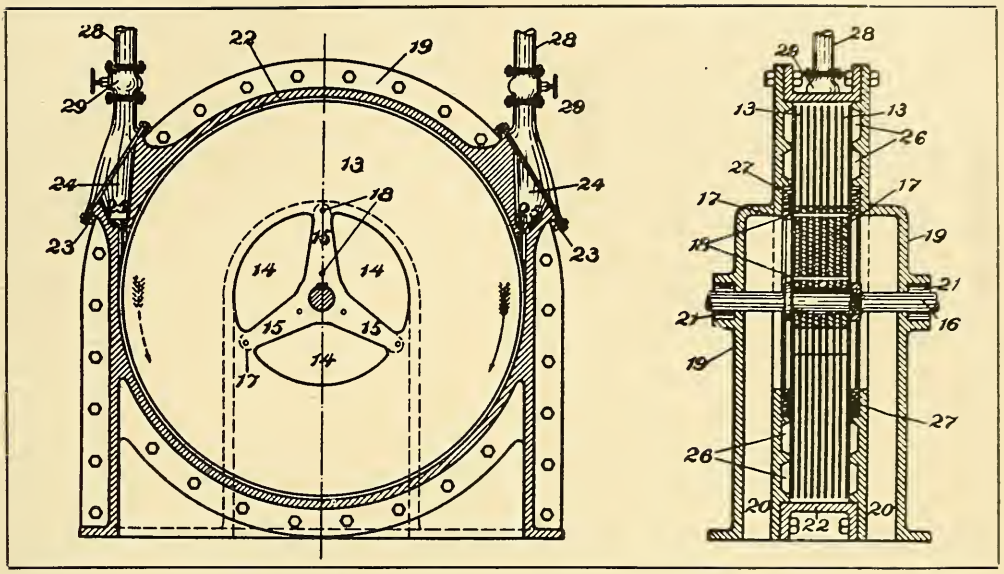


Fig. 3

Fig 4

Sectional Views of Turbine

and suitable for high as well as for low fluid velocities and speeds of revolution. The principles of construction and operation are capable of embodiment in machines of the most widely different forms and adapted for the greatest variety of purposes."

Ordinarily engineers look upon friction as a thing to be avoided and yet at first sight it would seem as if Tesla relied upon friction to operate his motor. "This new principle * consists simply in the utilization of the fluid's internal friction and its adhesion to a smooth surface for giving it speed or imparting to machinery its speed already acquired. The operation is thus vastly smoother than in any known pump or engine, and wasteful and injurious jerks are eliminated, as well as complicated parts." It is interesting to note Tesla's own description of the action of his motor.**

"It is known that a fluid possesses, among others, two salient properties; adhesion and viscosity. Owing to these a body propelled through such a medium encounters a peculiar impediment known as "lateral," or "skin resistance," which is two-fold: one arising from the shock of the fluid against the asperities of the solid substance, the other from internal forces opposing molecular separation. As an inevitable consequence a certain amount of the fluid is dragged along by the moving body. Conversely, if the body be placed in a fluid in motion, for the same reasons, it is impelled in the direction of movement.

"In the practical application of mechanical power based on the use of a fluid as a vehicle of energy it has been demonstrated that, in order to attain the highest economy, the changes in velocity and direction of movement of the fluid should be as gradual as possible. In the present forms of such apparatus more or less sudden changes, shocks and vibrations are unavoidable. Besides, the employment of the usual devices for imparting to, or deriving energy from a fluid, as pistons, paddles, vanes and blades, necessarily introduces numerous defects and limitations and adds to the complica-

* *The Literary Digest*, October 28, 1911, p. 732.
** *Electrical World and Western Electrician*, September 9, 1911, p. 515.

tion, cost of production and maintenance of the machine.

"The purpose of the invention is to overcome these deficiencies and to effect the transmission and transformation of mechanical energy through the agency of fluids in a more perfect manner, and by means simpler and more economical than those heretofore employed.

"This is accomplished by causing the propelled or propelling fluid to move in natural paths or stream lines of least resistance, free from constraint and disturbance such as occasioned by vanes or kindred devices, and to change its velocity and direction of movement by imperceptible degrees, thus avoiding the losses due to sudden variations while the fluid is receiving or imparting energy.

"The greatest value of this invention will be found in its use for the thermodynamic conversion of energy. Reference is now made to Figs. 3 and 4,* illustrative of the manner in which it is, or may be, so applied.

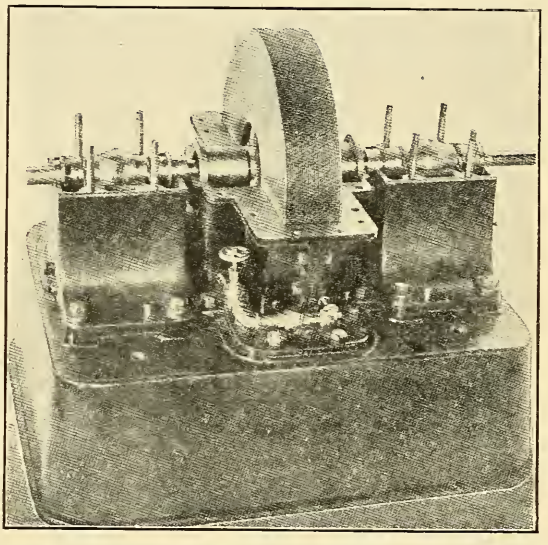


Fig. 5. Turbine with upper casing removed. The cluster of thin disks looks like a solid wheel

"A runner is provided made up of disks (13) with openings (14) and spokes (15) which, in this case, may be straight. The disks are keyed to and held in position on a shaft (16), mounted to turn freely in suitable bearings, not shown, and are separated by washers (17) conforming in shape with the spokes and firmly united thereto by rivets (18). For the sake of clearness but a few disks, with comparatively wide intervening spaces, are indicated.

"The runner is mounted in a casing comprising two end-castings (19) with outlets (20) and stuffing boxes (21), and a central ring (22), which is bored out to a circle of a diameter slightly larger than that of the disks, and has flanged extensions (23) and inlets (24) into which finished ports, or nozzles (25) are inserted. Circular grooves (26) and labyrinth packings (27) are provided on the sides of the runner. Supply pipes (28), with valves (29), are connected to the flanged extensions of the central ring, one of the valves being normally closed.

"With the exception of certain particulars, which will be elucidated, the mode of operation will be understood from the preceding description. Steam or gas under pressure being allowed to pass through the valve at the side of the solid arrow, the runner is set in rotation in clockwise direction.

"In order to bring out a distinctive feature assume in the first place that the motive medium is admitted to the disk chamber through a port, that is, a channel which it traverses with nearly uniform velocity. In this case, the machine will operate as a rotary engine, the fluid continuously expanding on its tortuous path to the central outlet. The expansion takes place chiefly along the spiral path, for the spread inward is opposed by the centrifugal force due to the velocity of whirl and by the great resistance to radial exhaust. It is to be observed that the resistance to the passage of the fluid between the plates is approximately proportional to the square of the relative

* *Electrical Review*, p. 316.

speed, which is maximum in the direction towards the center and equal to the full tangential velocity of the fluid. The path of least resistance, necessarily taken in obedience to a universal law of motion, is virtually, also that of least velocity.

"Next assume that the fluid is admitted to the disk chamber not through a port, but a diverging nozzle, a device converting, wholly or in part, the expansive energy into velocity-energy. The machine will then work rather like a turbine, absorbing the energy of kinetic momentum of the particles as they whirl, with continuously decreasing speed, to the exhaust.

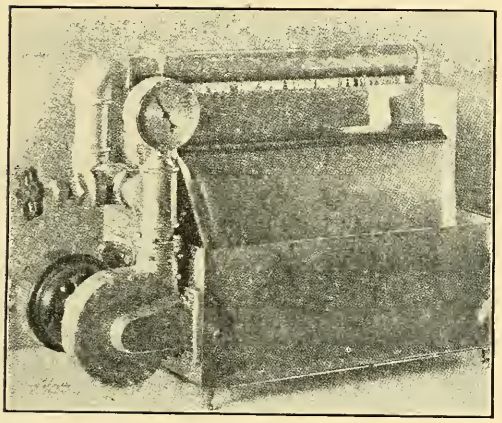


Fig. 6. This little pump, driven by a $\frac{1}{12}$ horsepower motor, is shown delivering 40 gallons of water a minute against a 9-foot head

"The above description of the operation is suggested by experience and observation and is advanced merely for the purpose of explanation. The undeniable fact is that the machine does operate, both expansively and impulsively. When the expansion in the nozzle is complete, or nearly so, the fluid pressure in the peripheral clearance space is small: as the nozzle is made less divergent and its section enlarged, the pressure rises, finally approximating that of the supply. But the transition from purely impulsive to expansive action may not be continuous throughout, on account of critical states and conditions, and comparatively great variations of pressure may be caused by small changes of nozzle velocity.

"Still another valuable and probably unique quality of such motors or prime movers may be described. By proper construction and observance of working conditions the centrifugal pressure, opposing the passage of the fluid may, as already indicated, be made nearly equal to the pressure of supply when the machine is running idle. If the inlet section be large, small changes in the speed of revolution will produce great differences of flow which are further enhanced by the concomitant variations in the length of the spiral path. A self-regulating machine is thus obtained bearing a striking resemblance to a direct-current electric motor in this respect, that, with great differences of impressed pressure in a wide open channel the flow of the fluid through the same is prevented by virtue of rotation. Since the centrifugal head increases as the square of the revolutions, or even more rapidly, and with modern high-grade steel great peripheral velocities are practicable, it is possible to attain that condition in a single-stage machine, more readily if the runner be of large diameter. Obviously this problem is facilitated by compounding. Now, irrespective of its bearing on economy, this tendency which is to a degree common to motors of the above description, is of special advantage in the operation of large units as it affords a safeguard against running away and destruction."

Tesla claims that his machine if driven by external power may also be used as a pump, either for delivering water against a head, or for compressing gas. When considerable pressures are required, staging or compounding may be resorted to in the usual way. The last illustration * shows a small pump driven by a motor of 1-12 horse-power which delivered forty gallons of water per minute against a nine-foot head.

In these machines the stream impact used in turbines has apparently been

* *Scientific American*, September 30, 1911, p. 296.

A view of the Austin (Pa.) Dam from down stream. Illustration from the *Engineering Record*

replaced, at least to a certain extent, by the direct impact of the individual gaseous molecules against the molecular inequalities of the rotating disks, but as the spaces between the successive disks are considerable there must still exist a relative displacement between the gaseous molecules at the center and at the surfaces of the stream, so that fluid friction losses must occur. That is, in this new type of motor, as well as in the turbine, there must be a continual dissipation of kinetic energy of translation in the direction of stream flow into the erratic vibration representing heat. The process will thus involve a growth of entropy with a resulting loss of availability. It is difficult to be as optimistic with reference to this motor as the inventor appears to be, but it is well to remember that it possesses such obvious mechanical advantages over the ordinary reciprocating and turbine engines as to secure it a permanent position as a prime mover, even if its thermal efficiency should prove to be considerably less than that of the present types. If, on the other hand, its thermal efficiency should prove to be equal to or better than that of the present engines, its advent will herald the beginning of a new order of things. There will exist but small excuse for complicated valve construction with reciprocating engines, and none whatever for the present turbine constructions. Therefore, considering the evident mechanical simplicity of this motor, as well as the uncertainty as to its steam economy, the engineering public is entitled to await with unbiased mind the publication of experimental data obtained under rigorous test conditions.

The mechanical engineering department of the Massachusetts Institute of Technology hopes before long to be able to furnish such data, as Mr. Tesla has kindly offered to furnish one of his two-hundred horse-power motors to Mr. E. C. Schell, 1912, for his thesis investigation.

AFRICAN RAILROAD BUILDING

Reports from the African Midland Railway would indicate that construction trains were running to a point about 450 miles west of its eastern terminus, Dares-Salem, during the month of September. This would leave about ninety-three miles to be built to reach Tabora which is 160 miles directly south of Lake Victoria. The Colonial Government hopes that the Reichstag will provide means for the further extension of about 200 miles to Uji-ji on Lake Tanganigika giving a line nearly 700 miles long from the Indian Ocean westward.

This road is about 500 miles south of the equator. Africa is about 1,800 miles in breadth on this parallel.

In a test on reinforced concrete piles made with a wood core surrounded by concrete and wire mesh, they showed a breaking load of 210 tons, equal to 3,118 pounds per square inch. The test piles were 19½ feet long and had an area of 154 square inches at the small end.

THE PRINCIPLE OF RELATIVITY

THE NEW IDEAS OF SPACE AND TIME WHICH HAVE MARKED AN EPOCH IN THE MODERN THEORY OF PHYSICAL PHENOMENA

BY D. F. COMSTOCK

WITHIN the last few years no new conception of things in physical science has been so widely, or for that matter, so hotly discussed as the so-called "Principle of Relativity." The principle has come into existence through generalization from a great many experimental results and has therefore more than an aesthetic dignity. The general nature of the conceptions comprizing the so-called principle may be stated in a few words thus. Both space and time are relative and depend on the point of view. The distance between two fixed points or the time between two events depends entirely on the relative motion of the observer who wishes to make the measurement. A moving train is actually shorter than the same train at rest and the watches of all the passengers run a little too slow, these things being true because of the very nature of time and space. In the case of the train the differences are far too small to notice but it nevertheless serves as an example.

All this is very vague, no doubt, but we hope to make things more definite as we proceed.

Considerations respecting space and time have in general been supposed to be the exclusive business of philosophers, but singularly enough, the development of physics has gone on so far toward the fundamental in the past few decades, that physicists are forced, whether they will or no, to play philosopher to this extent at least and to reconsider with care these fundamental realities. The curious and interesting thing, however, is that the physicist has not gone "hunting trouble" as it were, in this respect, but has been forced to adopt new space and time conceptions by the very experiments which he is carrying out on his laboratory table. Thus, led by experiment, and continually relying on it, he is advancing on to ground which a few years ago would have been called metaphysical and into a region extremely fundamental into which it has generally been thought experimental inquiry could never go.

A further curious and important fact about the results reached is that our ordinary, vague, common sense ideas of space and time are not *quite* in harmony with the new ideas taught by experiment. I have emphasized "quite" because they are very nearly in harmony, and it will be a long time before the differences between the two will be felt in the work-a-day world, if indeed, they are ever felt. But to those who are not satisfied with the superficial view of "the man in the street," the deviations are of very great importance because they require our fundamental conceptions to be somewhat modified.

Of course, new ideas which disturb somewhat the old familiar notions of time and space, cannot make their appearance and propagate without a great deal of opposition. And this has been noticed on all sides; under the flag of "The principle of relativity," there have been a great many battles fought of late, but there is this curious fact to be observed as to the personnel of the combatants, that the opponents of the principle of relativity are chiefly those who by their own confession, have not studied the question closely, or even studied closely the experiments on which the ideas are based. In some ways, the present discussion on the principle of relativity reminds one of the story of the early days of the

NOTE. The same author has written a popular article dealing with the elementary mathematics of the principle of relativity, which was published in *Science*, May 20, 1910.

Copernican theory, and as at that time, so now, the weapons of the opposition are the old familiar weapons of conservatism and do not include among them any new ones of recent manufacture.

Having thus discussed in a general way, the general bearing of the new ideas, let us come down definitely to their nature. The keynote of the new principle is, that *two events which to one observer appear simultaneous will not so appear to another observer if he is moving with respect to the first.* To make use of a very crude analogy, suppose a man riding on a train passing a station and a boy standing at each end of the station and now suppose the two boys blow whistles at the same instant. Then if all measurements could be made with superhuman accuracy, the observer in the train would say that the boy who stood at the end of the station farthest in the direction in which the train was going, blew his whistle later than the other. This disagreement has nothing to do, whatever, with the question of the velocity of sound but is far more fundamental. From the modern point of view it is inherent in the nature of things. On the other hand, for the thing is completely reciprocal, if we imagine the man on the train, to arrange by means of delicate instruments or otherwise, two simultaneous events, one toward the front of his train, the other toward the rear, and to do all this with what I have called superhuman accuracy, an observer on the platform of the station would say that the two events were *not* simultaneous, but the one toward the front of the train had happened later than the other. Thus, whenever there is an appreciable distance between the places where two events happen, there is, according to the modern views, an ambiguity with regard to *when* the events happen, this ambiguity depending on the motion of the observer who passes judgment.

It is also true according to the principle of relativity that if the man in the train possessed a perfect clock, exactly similar to another perfect clock in the station, it would appear to run slower to an observer on the station platform, *no matter how he measured the speed*, while exactly an opposite judgment would be passed by the man in the train, namely, that the station clock ran slower. As has been already stated, it must be understood that these differences of opinion are not due to any faulty measurement, or to either observer being "wrong" in any way. The reason is far more fundamental than this, being, in fact, involved in the very nature of time and space.

The reason that this discovery, if we may call it such, as to the ultimate relations of space and time, was not made before, is, that the effects are so extremely small. The fundamental natural unit of velocity in the physical universe seems to be the velocity of light, 186,000 miles per second, and hence from nature's point of view, any velocity is "small" which is not somewhere near comparable with this enormous speed. The mathematical formula, therefore, which states *how much* more slowly the train clock runs than the station clock, contains the ratio of the velocity of the train to the velocity of light, which is so absurdly small that it could not possibly be noticed with any such crude arrangement as the one we have used for illustrative purposes.

It is also clear from the minute size of these discrepancies why there is to all of us a certain repugnance to accepting the new ideas. Our experiences have led us to think of time as absolute and totally independent of the point of view, because our experiences totally neglect any but large and crude effects. In this same way, primitive man doubtless overlooked for years the fact that hot bodies are as a rule larger than the same bodies cold. We may easily imagine a primitive man arguing, if he could argue, that it was clearly ridiculous that the same piece of stone could have any but one fixed size, and having been forced by the cold facts to admit, that nevertheless the same body can grow larger by being heated, accepting the "new ideas" with the greatest repugnance.

As far as primitive intuitions go, the new ideas of the principle of relativity may never be as easy to assimilate men-

tally as the old ideas. Our experiences have all been with speeds which from nature's point of view are very minute and the principle of the new ideas would never have come into existence were it not for the study of phenomena involving vastly greater velocities.

We have a rather close analogy in the dawn of the idea of the round earth. As long as men had experience only in small areas, the earth appeared flat, and even now for all their daily experiences in the work-a-day world, it *is* flat, but the exploration of vaster regions, both terrestrial and astronomical, showed that the simple idea of a flat earth was wrong. The analogy, however, goes further; for, despite the verbal familiarity of the idea of a round earth, the conception is not one which our minds take up easily, for no one can visualize clearly, as Herbert Spencer has so well pointed out, this inconceivably enormous sphere with its surface on which we stand spreading out in all directions, and finally curving until it meets 8,000 miles below our feet. We have, what Spencer calls, a "symbolic conception" helped by the memory of a little model held in our hands.

Had the earth been 10 miles in diameter instead of 8,000 miles, no one, except perhaps primitive man, would ever have had the conception of a flat earth, and similarly with respect to the new ideas, had the velocity of light been 300 feet a second instead of 186,000 miles, we would have had very different ideas of space and time.

The new ideas have thrown light on many phenomena hitherto in darkness. Thus there is a well-known experiment in physics of letting light pass through a rapidly moving stream of water and measuring with very delicate instruments how much the light is carried along with the water. Now beforehand we might expect one of two things, either the light is totally dependent on the water, in which case it would be carried along with it like a boat on a river or the light is independent of the water in which case the flow of the water would have no effect on the light as a river has no effect on an island in it. The experimental result is, however, quite different, for we find neither of these expected results but rather the very puzzling one that the light *is carried along* but with about *one fourth* the velocity of the water. From the principle of relativity, the case is clear, for, since motion is relative, an observer imagined moving with the water would see the light doing exactly what we see it do in "stationary" water, and it is our fundamental disagreement with this moving observer which introduces the mysterious 3/16 into our measurement. How far is the sun from the zenith? The answer depends on the *place* of the observer. How fast does the light move through the water? The answer depends on the *motion* of the observer.

It would be inconsiderate of the reader if I multiplied further descriptions of experimental results and it must suffice to say that, so far there is not a *single* experimental result which seems to contradict the principle of relativity, while there are a great many experimental results which it explains with ease.

Doubtless much of the foregoing will not be clear, but the reader can have this consolation at least, that difficulty in dealing with the principle of relativity is felt by everybody at the present time, even by those who know the most about it. The ideas have not been simplified yet, have not, that is, been worked down into the form in which they fit easily into a high school physics, but we must remember that there was a time when no one understood the principle of the conservation of energy very well, whereas now, it properly belongs in the most elementary books.

Already there is a German book with "The Principle of Relativity" as its title, and in English text-books we may expect at least a chapter with this title before long. At any rate, the principle represents a series of extraordinary concepts, apparently in deeper harmony with the real world than the corresponding older ones, and a distinguished European scientist goes so far as to say that the principle of relativity can only be compared with the Copernican system in the far-reaching nature of its implications.

THE SMALL CAVE HOUSES OF ARIZONA

RELICS OF A PEOPLE THAT LIVED IN THE CLIFF DWELLINGS OF WALNUT CANYON MORE THAN A THOUSAND YEARS AGO—PROBABLY ANCESTORS OF PUEBLOS

BY H. W. SHIMER

Walnut Canyon is one of the more easily accessible of the many localities of the southwestern United States where cliff dwellings occur. One may walk or ride the eight miles from the railroad station of Flagstaff out through a pine-clad, rolling upland until quite suddenly the trail ends at the edge of a gorge 350 feet deep. At first glance one sees only the steeply descending sides, with small pines and undergrowth clinging closely to the talus slopes of the softer strata. Directly, however, one distinguishes three horizontal, cave-like grooves running along its face and about half way up from the bottom of the gorge and in each groove artificial walls, dividing it into separate compartments.

Walnut Canyon, 350 feet deep, and the pine-clad rolling upland into which it is cut

The geologic structure of the region explains the formation of caves and their adaptability for occupation as homes. The gorge has been cut into a plateau of upper carboniferous rocks. Above the cross-bedded sandstone into which the lowest part of the gorge is cut, these rocks consist of horizontal beds of limestone of varying hardness. This variation in hardness renders the successive layers variable in their resistance to weathering, the more resistant remaining as ledges projecting out over the softer, more easily eroded bed below. It is in three such cave-like grooves formed by the erosion of the softer rock between these resistant beds that the cliff dwellings occur, a compact bed of limestone some twenty feet thick forming the roof, while another resistant bed forms the floor. These cave layers extending along the steep slope of the canyon are divided into separate dwellings by transverse walls built out from the back to the front of the cave.

One house of average size measured 15 feet in length, 10 feet in width or depth, and from 7 feet in height at the front to 4 feet at back. The floor had been made approximately level by filling in the down sloping front part with mortar. The

front of the house is an artificial wall two feet thick built of native rocks of varying sizes joined by a yellowish brown mortar of rather coarse sand such as is found in the bottom of the canyon. This front wall reaches from the floor to the overhanging ledge and is pierced at the center by a door nine inches wide at base, which though now broken away above was apparently originally less than five feet high. Against the roofing ledge directly over the door is a round hole of four inches diameter, apparently a smoke outlet. The transverse walls forming the ends of the house are similar in thickness and material to the front wall which they join at a right angle.

That the fire was built in one of the back corners of the house is evidenced by the soot on the adjoining walls and roof and by the presence of charred corn cobs, bones and bits of wood. Fragments of pottery indicating vessels of many sizes and shapes from jars to platters are extremely abundant both in and about the houses, especially on the slopes in front.

A Walnut Canyon cliff dwelling showing the resistant stratum above and the character of the masonry.

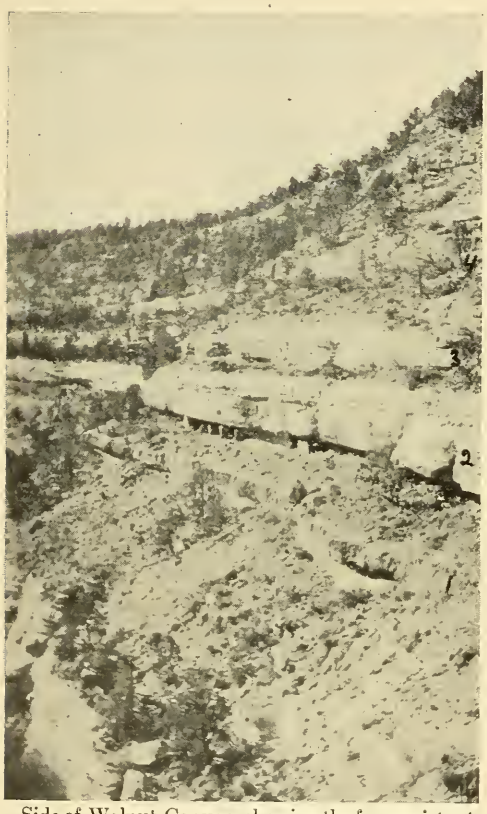
There were doubtless many tribes of this ancient Indian stock varying in degree of culture and in the development of communal life. Many large community cliff houses have been found in the southwestern United States and remains of artificial irrigation canals. Such remains indicate the development of a greater co-operation than do the small cave houses developed in response to the conditions at Walnut Canyon. In this plateau region the horizontal bedding and alternate hardness of the rocks form caves and in response to these natural conditions the cliff-dwelling type of house arose, just as the polar region developed the snow house, treeless plains the portable tents of skin, and broad dry valleys, mud or adobe houses. Doubtless, likewise, the nomadic tribes to the north made utilization of these caves necessary for the self-preservation of these more peaceable Indians of Pueblo stock.

Our knowledge of the life of these builders of the Walnut Canyon houses has been amplified by remains found in the other cliff houses of supposedly kindred peoples. They made much pottery, probably mostly of the type formed by coiling long clay rolls round and round in the shape of the jar desired. Of the fibers of yucca leaves they made sandals and wove cloth. That they were not an aggressive people seems indicated by the relative scarcity of weapons among the cultural remains. No iron implements have been found, hence they were probably wholly in the stone age of development. Their chief weapon apparently was the flint-headed arrow. Their food included deer and turkey, corn, beans and melons.

The abandonment of these homes by their once numerous inhabitants is generally explained by the gradual encroachment of desert conditions into this southwestern region. Such a process of drying up is indicated at present by the dead

forests and by the lack of young growth in much of the existing forests. It is considered that the water courses have gradually shrunken and the area of tillable land has decreased, so that the country can no longer support such a population as formerly existed.

Most investigators agree that these dwellings have been deserted for about



Side of Walnut Canyon, showing the four resistant beds, numbered, between which the dwellings occur. Most of the dwellings are between the lower beds; a few show in the picture

1,000 years. The dwindled survivors of this people may possibly have been the ancestors of the present Hopi Indians and other Pueblo tribes of Arizona and New Mexico.

The Massachusetts Institute of Technology has received the equivalent of two and three quarter million dollars during 1911.

THE SIBERIAN RAILWAY

The balance sheet of the Siberian Railway shows that it is not a very profitable enterprise. For the three years beginning 1906, the operating expenses were successively 144 per cent. 139 per cent and 124½ per cent of the gross earnings. The deficit in 1908 was $6,693,000, to which should be added interest on the capital stock which is $235,292,862, to find out what Russia is paying for the development of its Asiatic territory and for national defence.

There is some development of earnings on that part of the line which is west of Lake Baikal, which alone the Russians call the Siberian Railway. The line east of the lake is called the Trans-Baikal, and the 570 miles on the Pacific coast from Vladivostock northeastward, the Ussuri Railway. The earnings of these last two have decreased materially since 1906; but the Siberian proper actually had some net earnings in 1908; about $488 per mile, against a deficit of $692 in 1907. There is a considerable amount of cultivable land along this line, and it is nearer the markets for its wheat, butter, etc.

SCIENCE HELPS THE FISHERMEN

It is stated that the Danish Government, under the direction of the biological department at Copenhagen, has come to the aid of the fishermen of the Baltic Sea by providing an ingenious device for the preventing of migration of eels from that arm of the sea to the outer ocean. The *Electrical World* states that the means employed is a barrier of light, formed by placing fifty electric lights along a submerged cable between the island of Fano and the coast of Funen. The eels migrate only during the dark hours, and, accordingly, as soon as darkness begins in the season of migration the lamps are illuminated and a wall of light is thus interposed which the eels are fearful of passing. A similar plan, using submerged lamps, is said to be a favorite resort of Italian fishermen to keep eels from leaving the shallow waters.

LIQUID CRYSTALS AND THEIR FORMATION

INANIMATE BODIES WHOSE GROWTH IN SOLUTION RESEMBLES THE DEVELOPMENT OF LIVING CELLS—SOLIDS AND SUPERCOOLED LIQUIDS

BY ELLWOOD B. SPEAR

To most of the readers of Science Conspectus, the words "solid" and "liquid" carry their own definitions so far as the everyday matters of life are concerned. Webster's definition of solid is,—"capable of resisting up to a certain limit, forces tending to deform," and his definition of liquid is,—"flowing freely like water, fluid, not solid," and as applied to physics, "characterized by free moving of the constituent molecules among themselves, but without the tendency to separate from one another characteristic of gases."

Solids and Liquids

These definitions do very well for dictionary purposes but in order to show how faulty they are for the uses of science, let us consider a common example. White sugar is obviously a solid, and water a liquid. Further, when the sugar is dissolved in water, doubtless the mixture is a liquid also. If now, we boil this mixture, it gradually becomes thicker and thicker until it reaches a point where, upon being rapidly cooled, it becomes candy having a clear glass-like mass that is apparently solid. If the hot mixture is a liquid, and the cold candy a solid, the question naturally occurs, at what stage of the cooling did the liquid become a solid. This mass of candy is not absolutely rigid and resistant to a change of shape, for even the hardest will bend slightly when pressure is gradually applied to it. If we reheat the mass, it will gradually become softer and if we consider the mass as a solid, there is no definite temperature at which we can say that it has become a liquid.

Suppose we suddenly cool the mass once more and "pull" it as candy is ordinarily pulled. The mass will become whiter and stiffer until it can no longer be pulled without breaking it. If we attempt to heat this pulled candy a second time, we should find that there is a definite temperature at which the solid suddenly changes into a liquid state. Most bodies have a definite melting temperature which scientists use as one criterion to determine the transition from one state of matter to another.

Supercooled Liquids

There are some substances, however, which do not quickly change from the solid to the liquid, and *vice versa*, at a definite temperature on being heated. Such substances are called supercooled liquids; the candy was a liquid cooled below the temperature at which it will easily flow. Glass is an excellent example of a supercooled liquid. If a long piece of window glass be held horizontally at one end for a considerable period of time it will bend of its own weight showing that its molecules have changed positions somewhat. This change in the molecules is similar to the change in the molecules of a liquid, and metals which are made to assume various shapes under the drop hammer or drawing press are said to "flow."

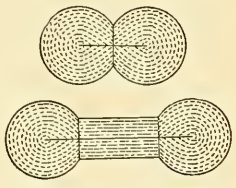
True Solids

The question may now be asked, is there any fundamental difference of structure between the so-called supercooled bodies and true solids? To enable us to answer this question, let us examine a little more closely a piece of the candy before and after it has been pulled. If we break it with a hammer before it has turned white, we notice that there is no

uniformity in the shape of the pieces. The corners and edges of a fragment form all sorts of angles with each other. On the contrary, the white pulled taffy if broken will resolve itself into numberless small pieces having certain angles and corners that are exactly the same on every piece. These angles are absolutely independent of the size because even if the substance is ground into powder, we should find that under the microscope, each particle has some angles that are an exact reproduction of the corresponding edges on the parent fragment. This is a general law, that every true solid will break along certain lines much more readily than along others. These are called "lines of cleavage."

Crystals

Let us again melt some sugar and allow it to cool very slowly. This time we obtain a large number of small bodies exactly alike in shape having the same angles as our powdered white sugar. We have here to do with another general law, that all true solids assume certain definite shapes if but given an opportunity. Table salt, for instance, always occurs in cubes while sulphur resembles double pyramids. There are only thirty-two of these fundamentally different forms and all others found in nature are either these or combinations of these.



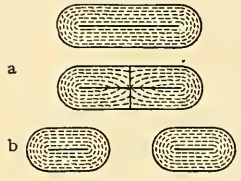


Fig. 1. A diagram showing how some liquid crystals grow, divide into halves and separate in the same manner as living cells

Scientists have offered in explanation of this peculiar behaviour on the part of true solids, that the molecules arrange themselves along certain definite lines. In mobile liquids the molecules are free to move in any direction and are vibrating too rapidly to assume any definite arrangement, but if the liquid is cooled slowly, that is, if the molecules lose some of their kinetic energy,* the forces governing this definite arrangement of molecules get control and the molecules become orderly in their habits once more, forming a body having definite shape. True solids, then, are bodies whose molecules, or groups of molecules, arrange themselves in a definite geometrical manner. A solid is therefore said to be crystalline and each individual fragment is called a crystal. Supercooled liquids on the other hand are hard bodies whose molecules have no definite arrangement and are spoken of as amorphous, meaning without form.

We now see the reason why we can have sugar in two hard forms. If we cool melted sugar so quickly that the molecules do not have time to assume the position they like best, we have clear, amorphous candy. If, however, we pull and work this mass long enough, the molecules, can swing around into a suitable position and we have "pulled" candy which is none other than crystallized sugar. For precisely the same reason that candy crystallizes and becomes sugar, automobile springs break after they have been used for some time. The steel of which they are made is generally "hardened" by plunging the hot metal into water or oil. If the spring is constantly jarred, the molecules gradually assume a more orderly arrangement. Some of the substances in the steel become cyrstalline, and the spring breaks along the lines of cleavage of the crystals.

Liquid Crystals

Of late years, many liquids have been found to have a definite arrangement of the molecules just before the solid form is reached; that is, if the pure liquid substance is kept for some time at a temperature very slightly above that at which the whole mass becomes a solid, liquid bodies like crystal ghosts, are formed and these

*See Science Conspectus, Vol. I, page 51.

bodies have been given the name *liquid crystals*. Most of these substances are of a very complicated structure and have names that are unintelligible to any but a close student of the subject. (See Fig. 3.)

Resemblance of Liquid Crystals to Living Cells

Liquid crystals possess some very interesting properties so nearly allied to the habits of organic life that some scientists have suggested the possibility that these peculiar bodies are an intermediate step or a missing link between living things and inanimate matter. Indeed, no one can watch the formation of some liquid crystals under the microscope without being struck with the marvelous similarity between this method of growth and that of all living matter.

All living things, trees for instance, are composed of tiny particles called cells. These cells absorb molecules of suitable substances which penetrate into the inside and are assimilated just as animals eat and assimilate food. When now, the cell becomes too large, it divides in the center and becomes two new cells just as bees divide into swarms and leave the old hive when their numbers become too great. This is called cell division and is the method by which all animate matter grows. Ordinary *solid* crystals can be made to grow, it is true, but the new matter is always deposited on the outside of the crystal. Liquid crystals on the other hand, absorb molecules of the same substance into the inside of the crystal just as living cells do. Very often the crystal divides into two parts and these repeat the process of division as soon as they have absorbed sufficient material. The two halves often remain united by a band and subsequent growth begins at both ends. Sometimes the increase in size is very much greater in one end than in the other or takes place faster on one side of the crystal. This gives a wiggling motion to the whole particle. If this distorted growth is very rapid, it appears to the observer as though tiny snakes were being formed in the solution with incredible rapidity. Figures 3 and 4 are actual photographs of living crystals in the process of growth.

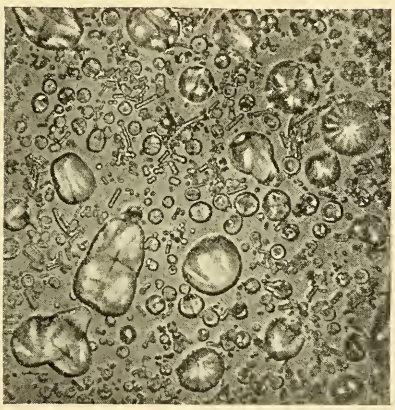


Fig. 3.

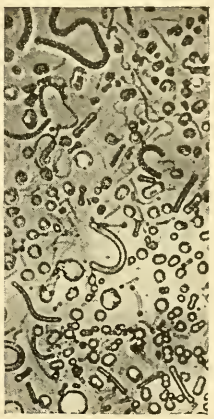


Fig. 4.

Actual photographs of liquid crystals of para-azoxycinammicethylester in process of formation. In the right hand one can be seen the wiggling worm-like bodies already referred to

EROSION OF BRITISH ISLES

The erosion of the British coast has been studied by a royal commission which has recently handed in its report. Six thousand six hundred and forty acres have been eroded within a period of thirty-five years, while 48,000 acres have been gained by accretion and reclamation. The loss has been more serious on the east coasts of England and Ireland, but it is not sufficient to cause alarm.

THE MILK SUPPLY OF BOSTON

DANGERS OF THE MILK SUPPLY AND WATER SUPPLY COMPARED—CERTIFIED AND PASTEURIZED MILK—RIGID INSPECTION BY CITY AUTHORITIES

BY SAMUEL C. PRESCOTT

We are inclined to think of water supply and sewage disposal as the great sanitary problems of cities. Important as these are, the questions of proper milk supply, proper food supply, proper housing, and proper regulation of the dangerous, infected, or diseased individuals will appear of equal gravity when we study them from the standpoint of general community welfare, and note accurately the relation of each to the health of the citizens.

This paper, however, can touch only on one of these subjects, milk supply,—and this in but an incomplete and superficial way.

Milk is perhaps, next to water and bread, our most important food substance, for it is a commodity of almost equally general use. For the very young it is a necessity, for it is the natural food. It contains all the elements necessary for the upbuilding of the body, and it contains them in combinations and proportions which make it, under normal conditions, a perfect food. This matter of composition in itself is of the utmost importance, because with our increasing knowledge of bacteria, germs, or microbes, we have learned that more than almost any other food, milk may readily be changed from a substance of the highest value to a most dangerous and death-breeding medium if it happens to become infected with pathogenic or disease-producing organisms. Fortunately the worst types of these infections are relatively rare, or we should be constantly having epidemics due to this cause.

As compared with the water supply of a city the milk supply problem offers certain points of similarity and others of marked contrast.

Let us follow the development of each as a community passes from rural to urban conditions. Under rural conditions the water supply is the shallow well, or a near-by spring or brook. Under the same conditions the milk supply is the family cow or herd, essentially, however, a domestic supply. With village conditions the wells may be retained, or a not remote river, or springs or wells may be tapped for the general supply. The milk supply in like manner is removed away from the actual household environment, but still relatively near and easy of access so that the milk may still be obtained in a fresh if not in a clean condition. With the large city the sources, in each case, are pushed still further away, as the demands for quantity increase, and as the suburban regions become too valuable to be given up to uninhabited watersheds or even to dairy farms. In this factor of distance from consumer, then, and in the demand for quantity, water supply and milk supply for a large city are alike, but here the analogy ends, for having thus reached out into a remote region, the water supply is, in general, in a sparsely settled region, and not subject to the contamination or pollution due to intimate contact with human beings. A watershed may be subjected to sanitary supervision and control, and the matter thereby protected in great measure. Is this true in milk supply? Assuredly not. Hardly any substance which enters our mouths as food is more subject to contamination;—from dirty cows, from dirty utensils, dirty men and dirty methods. So obvious is this, in fact, that many people never really know the true taste of clean cow's milk, and always assume that the *cowy* tang is the real taste rather than the flavor of the dissolved and suspended cow manure.

Now, there is another point of difference. Milk is an ideal bacterial food, while water is not. If therefore we have each of these commodities equally infected with intestinal bacteria the germs will die out gradually in the water, or be starved out, while on the other hand they will develop and increase with lightning-like rapidity in milk unless counteracted in some way.

In the matter of transportation to the city, too, there are great differences, and this has also a bearing on our general subject. The water is brought in by conduits or pipes, generally covered and protected from infection, and distributed to the consumer by service pipes, still protected. It is therefore either at the source or at the point of consumption that noxious germs may enter a water supply.

Milkshed E—Elm Farm Creamery

With milk, on the other hand, unless the most assiduous care is observed, the supply is subject to infection from human and other agencies at every point from the cow to the consumer; at the farm, on the road, on the railroad, in the milk-house, on the delivery wagon, and even in the very kitchen of the consumer himself. As a matter of fact this is probably in many cases a most important and dangerous point of infection.

It is because of these facts, combined with the almost universal use of milk, that those who are interested in health problems look upon the milk problem as one of the very greatest gravity, and for most cities far more serious than the question of water supply.

Evidence of the importance of this question is shown by the volume dealing with Milk Supply and Public Health, published by the Public Health and Marine Hospital Service in January, 1908, and reprinted in enlarged form in 1910.

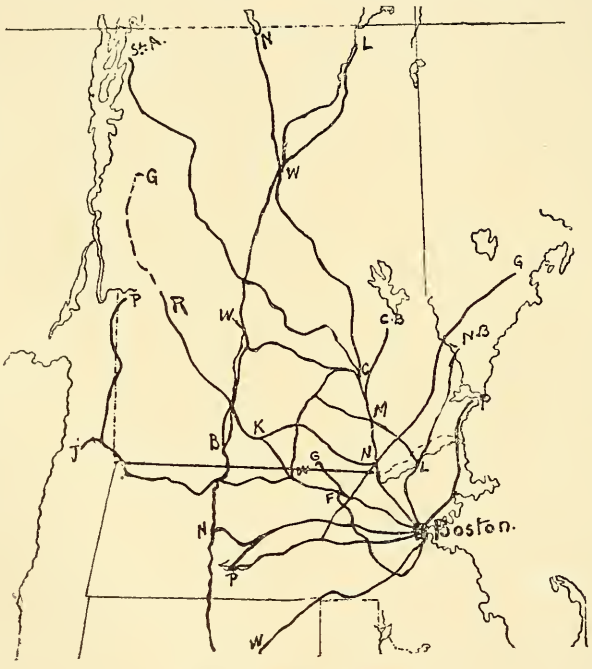
The importance of milk as an article of food may be considered from two distinct standpoints, first, from the actual standpoint of food substance or food value, second, from the standpoint of its safety and wholesome character.

From the first standpoint we should examine milk with reference to the amount of food, the amount of total solids, the proteins, and the amount of milk sugar. For the total solids and the fats definite standards have been formulated by the different states; in Massachusetts, for example, it is required that the milk shall contain at least 12.15 per cent of total solids, and 3.35 per cent of fats. Standards in other states depart somewhat from these figures. This variation in standards is due in part to the fact that we find great variation in the actual composition of cow's milk, and any standard, therefore, is but a compromise and represents simply, more or less fairly, the average composition of milk from all kinds of cows, or from the prevailing strain or breed. Different breeds of cows differ markedly in the relative amount of fat and of protein which the milk contains, and different animals in the same breed or strain also show great differences on these points. Since there are such wide variations to be found in the natural milk of healthy cattle it becomes reasonably apparent that the examination for fats and solids only is of no special importance, so far as the healthfulness of the milk is concerned, and the results of such examinations give us information only as to whether the purchaser is obtaining food which conforms to the specified state standards which have been erected. In other words, analysis of milk with reference to fats and solids is carried out simply as a means of protecting against fraud rather than from any standpoint of wholesomeness or effect on the health.

The examination of milk with reference to the number of bacteria and the kinds of bacteria contained in it has, however, a totally different basis,

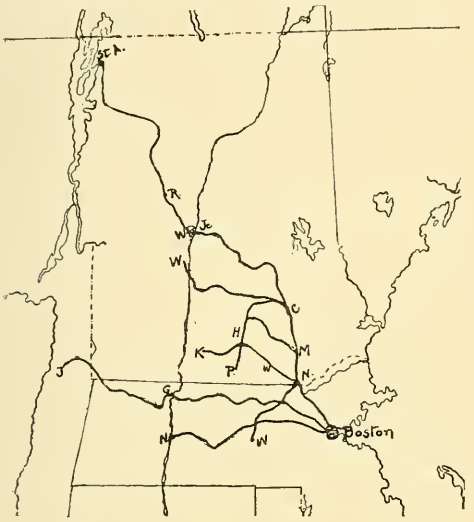
for it is now well understood that the wholesomeness of milk, or its effect upon the health of the consumer, is markedly affected by its bacterial character. Milk, as it is secreted by the healthy, clean cow, and obtained under clean conditions, shows very small numbers of bacteria, and these of types which produce change in the milk but slowly. If, on the other hand, the milk is obtained from dirty cows, with no special precautions as to cleanliness in production or in handling, the numbers may be very large and the kinds of bacteria may be very numerous. Furthermore, many of these kinds will have the power of bringing about a rapid change in the milk, fermenting the sugar to lactic acid, splitting the proteins to products of putrefaction or other forms of decomposition and affecting the fat, perhaps, also to a slight degree. Furthermore, the organisms themselves may be of such a character that when introduced into the human intestinal tract they produce serious disorders, particularly in children, and become a menace to health either directly or through the products of protein decomposition to which they give rise.

Milk obtained from clean, healthy animals under aseptic conditions may be called normal milk. Relatively small amounts of such milk are found in the supplies of great cities. Certain farms, however, make a specialty of producing normal milk, or approximately normal milk, by conforming rigidly to principles of cleanliness or to certain requirements which may be laid down by some organization such as the Medical Society, and such milk is generally spoken of as "certified" milk because it may receive a certificate as to its chemical and bacterial quality from such a commission. In many cities another grade of milk, not conforming to such rigid requirements as in the case of certified milk, but yet produced under clean conditions and under constant inspection, is sold under the general name of "inspected" milk. Such milk generally contains under 50,000 bacteria per cubic centimeter. By far the major portion of the milk sold in large cities, however, is subject to much less rigid inspection than this, and we therefore need not be surprised to find the number of bacteria far greater than these figures. Ordinary city milk, as it may be called, will sometimes be found to contain anywhere from a hundred thousand bacteria to hundreds of millions for each cubic centimeter, depending upon the demands of the enlightened portion of the public or the vigor with which milk campaigns have been waged by the health authorities. In many places the large numbers of bacteria are destroyed or held in check by the process of pasteurization, by which we ordinarily mean the heating of the milk to a temperature of from 140 degrees to 170 degrees for varying lengths of time,



The Milkshed of Boston

whereby the majority of the bacteria will be killed. True pasteurization consists in heating the milk to a temperature of from 150 degrees to 165 degrees for a period of from twenty to thirty minutes, and this process is extremely effective in

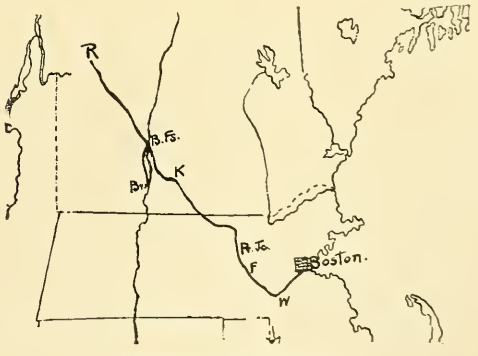


Milkshed A—D. Whiting Sons

the destruction of organisms since practically all, with the exception of the more resistant or spore-forming types, will be destroyed. Commercial pasteurization may be carried out, however, using these temperatures for very short periods of time, and while the destruction of bacteria is marked, the percentage of organisms destroyed will not be as great as in true pasteurization.

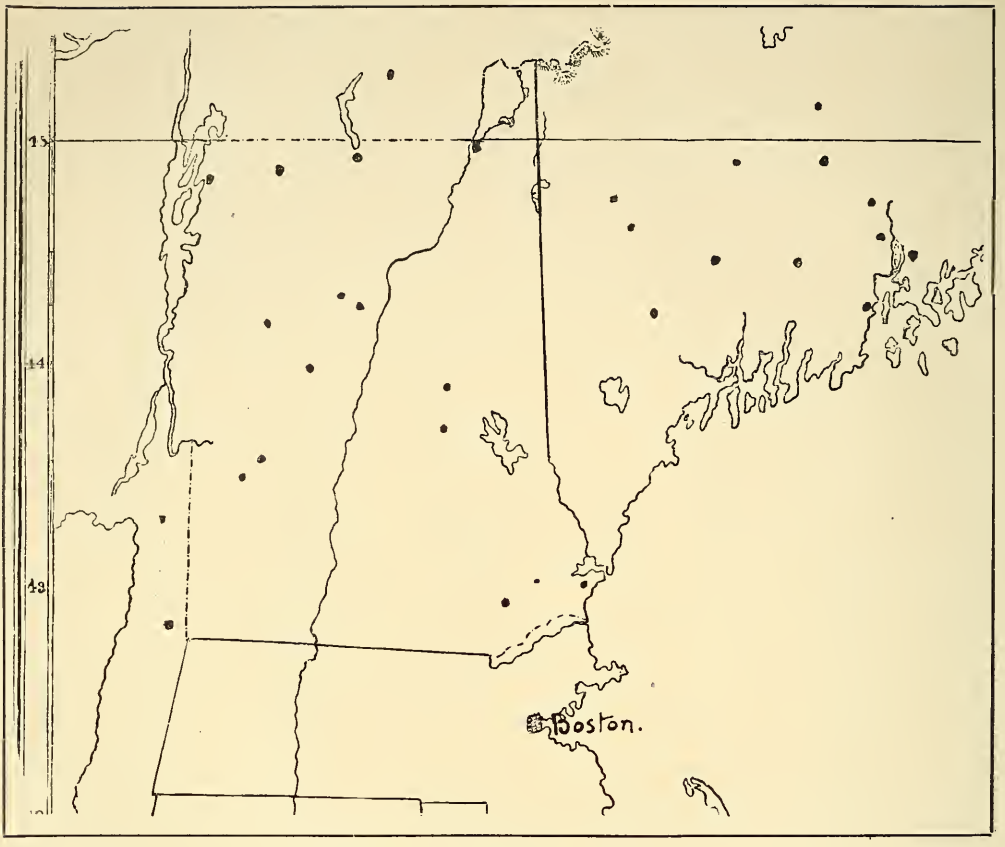
Having thus defined the kinds of milk with which the inspector or analyst has to deal we may consider the milk supply of Boston with reference to quality and the relative amounts of certified, pasteurized, and ordinary milk. According to the most recent available figures the average daily consumption of milk in Boston is slightly in excess of 250,000 quarts. For the whole metropolitan region this figure is nearly doubled. This vast quantity of milk is derived from between six and seven thousand farms scattered throughout the states of Massachusetts, New Hampshire, Vermont, and portions of Maine, New York and Connecticut. There are about two hundred and seventy-five dealers by whom the milk is sold to the consumers, although approximately 85 per cent of the business is really concentrated in the hands of less than a half-dozen large dealers, commonly known as contractors. Many of the smaller dealers buy their supplies direct from the contractors and serve merely as a second ring of middlemen between the producer and the consumer. Something less than half of one per cent of the whole milk supply of Boston, or about 1030 quarts daily is "certified" milk. Several thousand quarts daily would fall under the general head of inspected milk, were this term commonly used in this city. From 60 to 65 per cent of the whole supply of the Boston milk has been subjected to some process of heating with the intent of destroying the bacteria, although it is not sold under the name of "pasteurized" milk.

One of the most remarkable facts in connection with the Boston milk supply lies in the fact that almost three quarters of it comes from outside the state of Massachusetts, and much of it from great distances. The maps which are shown in this article give a general idea of the farthest shipping points and the routes over which the milk travels to reach the



Milkshed F—Alden Bros.

city. The farthest of these shipping points is Newport, Vermont, a distance of about 235 miles. The result of the fact that the city has to reach out so far into the surrounding country in order to



Some of the Foci of Cream Supply

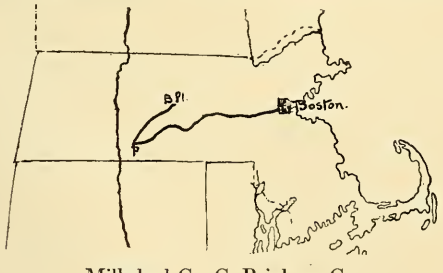
get an adequate supply is that the age of the milk when it reaches the city is likely to be considerable, and much milk is from forty-eight to sixty hours old when it gets to the doorstep of the consumer. Bearing in mind the great activity of the micro-organisms, it is not surprising that some of this milk should be of undesirable quality, and much of it would be unfit for food were it not for the fact that the process of refrigeration, and consequently of the inhibition of the bacterial development, had been brought up to a high standard of efficiency through the use of special milk cars with ice compartments and the liberal use of ice during the transit from the shipping point to the milk-house of the contractor.

In order to guarantee fair quality of milk to the consumer the city health department maintains an office and laboratory devoted to the subject of milk inspection. Here, samples amounting to approximately 20,000 per year, are submitted to analysis, part as to the proportion of fats and solids and a part with reference to bacterial count. About one third of the analyses are carried out from the bacteriological standpoint. These samples are collected by inspectors from the various dealers, from the cars as the milk is received in the city, or from delivery-wagons, or they may be taken from the various sorts of shops where milk is for sale. The larger dealers also maintain inspectors, chemists, and bacteriologists to look after their own particular portion of the supply. During the year 1909, 15 per cent of the chemical samples examined by the city milk inspector fell

below the legal requirement of either fats or solids or both. The bacteriological samples are examined to determine whether the total numbers of bacteria exceed an arbitrary number,—500,000 per

Milkshed G—Plymouth Creamery Co.

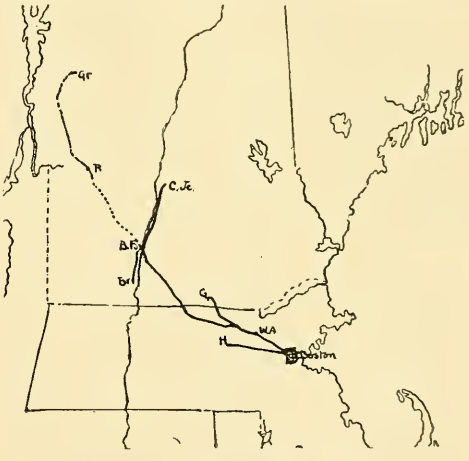
cubic centimeter—which the city board of health established several years ago, and during the year 1909, approximately 11 per cent of the bacteriological samples exceeded this figure. Notwithstanding this, it is unquestionably true that the Boston milk supply is much better at the present time than it was before the inspection work was conducted so assiduously, and it may furthermore be added that the Boston supply compares very favorably with the supplies of other large cities. It may fairly be questioned if any large city in the country has a general supply superior to that found here. The quality of the milk from the food standpoint will also bear comparison with that found in other cities. The average percentage of fat is about 3.5, and the average percentage of total solids from 12.3



Milkshed C—C. Brigham Co.

to 12.4, while in New York the corresponding figures are approximately 3 per cent and 11 per cent.

While, as stated above, the milk supply of Boston compares favorably with that of other cities, it is still capable of great improvement. The conditions on the farms are in many cases unsatisfactory, due to ignorance or carelessness on the part of the farmer, or sometimes due to labor difficulties, scarcity or high cost of assistance. Disagreements between producers and contractors as to the price to be paid and other features of the contracts between them, and the greatly increased cost of cattle feeds, have also tended to exert an influence on the whole question of quality of the milk and care in its production. If the farmer cannot receive a fair rate of compensation or a fair profit for his milk, he is, not unnaturally, unwilling to exert the increased care and clean-



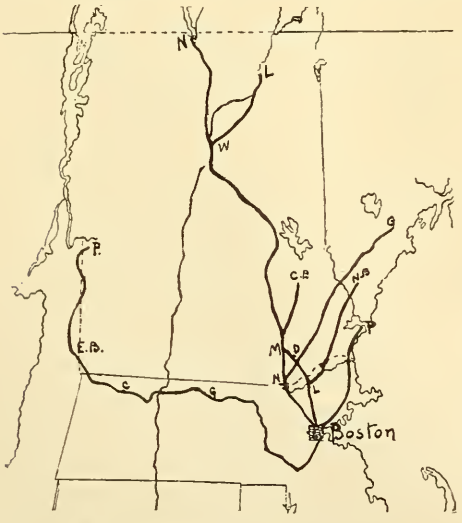
Milkshed D—Boston Dairy Co.

liness which the contractor, spurred by the city inspector, is constantly requiring.

A feature of the Boston milk supply which is more highly specialized here than in other cities is to be found in the method of handling after the milk reaches the city. During transportation the milk is contained most commonly in cans of 21 1-4 quarts capacity, or the familiar Boston can of 8 1-2 quarts capacity. On reaching the milk-house of the contractor the milk from possibly several hundred farms is dumped into a large tank provided with stirring apparatus, so that the quality, so far as fats and solids are concerned, may be reasonably

uniform. The bottling of the milk, therefore, instead of being done in the country is done in the city after this indiscriminate mixing has taken place. From the mixing tank the milk is pumped to the various other forms of apparatus,—heaters, coolers, filters, etc., and eventually finds its way to the bottling machines where it is put in the glass jars or bottles ready for distribution to the consumer. The milk-house has undoubted advantages in that a milk of relatively uniform quality is assured. There are, however, certain disadvantages, because if the milk from a particular farm is infected with the germs of disease these germs are distributed throughout the large volume of milk and so may go broadcast throughout the city.

The relation of milk supply to infant mortality cannot be discussed here, yet it should be borne in mind that these two subjects have a very intimate connection. We know that the cities having the clean milk supplies are those which have the lowest infant death rates, and it is probably true, also, that the more emphasis



Milkshed B—H. P. Hood & Sons

is placed on conditions of cleanliness at the farm, and especially in keeping the cows themselves clean and healthy, the more certain it is that there will be a direct and beneficial reaction upon the general health of the community. The time has come when the milk problem must be regarded as a most serious and important one, not to be settled by

Milkshed H—Deerfoot Farms Dairy

radical or foolish legislation, but by the united efforts of those who are concerned with milk production and sale as a business enterprise; those who are competent to deal with the problems of transportation and handling as engineering problems and particularly those who, through actual scientific knowledge and the results of investigation, can consider in a large and fair-minded way the general relation of milk to health.

THE CENTER OF POPULATION

Mr. E. Dana Durand, director of the Census Bureau, states that the center of population of the United States is located in the western part of Bloomington, Monroe County, Indiana. Since 1790 the center of population has moved 558 miles westward, but in the last ten years it has only moved thirty-nine miles in that direction. This is largely due to the fact that the population of New York, Pennsylvania, and some of the other near-by states has balanced the growth of Texas, Oklahoma, Indian Territory and southern California.

SOCIETY OF ARTS LECTURES

The lectures before the Society of Arts will begin in January. Arrangements for four lectures are being made but the total number may be increased to six. Due notice will be given to the Society.

SCIENCE CONSPECTUS

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SOME NEW FACTS ABOUT WHALES

PRINCIPAL GROUPS NOT RELATED TO EACH OTHER BUT ARE DESCENDANTS OF DIFFERENT LAND ANIMALS—DO WHALES EVER SLEEP

Smithsonian Institution JUL 22 1915 Astrophysical Observatory

IN A course of three lectures before the Lowell Institute Professor W. Kuekenthal presented a story of the whale which is perfectly up to date. In this he not only showed that many errors exist in popular conceptions, but that even important matters are not known to the investigators, for example, whether whales really sleep. The lectures abounded with items of general interest, which can be but hinted at in an account like this. With a word about the whales not being fishes Doctor Kuekenthal stated that they are descended from land mammals which have become modified in their life in the water, and further asserted that the fossil whales, now extinct, the whalebone whales and the toothed whales are descended at different geological times from different land animals. There is no link between the fossils and the toothed whales, and none between the latter and the whalebone whales. In this there was argued a principle of convergence, by which the animals from different sources adapting themselves to similar conditions resemble one another. This is the reason for the similarity between whales and fishes.

Some of the difficulties in the study of whales were shown, the fact that they cannot be confined in an aquarium, that they must be observed at sea, and that the ideas of those who are not scientists must oftentimes be discredited. The sailor, the speaker said, is not reliable as an observer of matters that do not directly interest him.

One of the things on which the lecturer threw light is the distribution of whales. They are not all of them marine animals, but some live in the brackish water at the mouths of rivers and others in the rivers themselves, hundreds of miles from the mouths. There is a dolphin in the Elbe, another in the Amazon and a third in the Ganges, the last named of which is eyeless or with the eyes atrophied.

Another difficulty in the study of whales is that they are heavy and their organs are unwieldy. The great mass of flesh when it decays makes such stenches that dissection is carried on with difficulty.

The distribution of the whale is practically universal. Some are special to the Arctic oceans, but in general, now that the species are being closely studied, the evidence shows them to be limited only by the food supply and they will go wherever this food is to be found. They swim all the time, are true pelagic ani-

mals, but are limited in their approach to the shores by shallow water and rocky projections. The number of species is not known, it having been a habit of the naturalists to give species from different localities different species names. It is evident that some kinds are common to the two oceans and the speaker noted that about two hundred and fifty species have been named of which perhaps ninety are valid. There is great variability, the males, females and young having different forms and in the opinion of Professor Kuekenthal, there is cross-breeding, although this is difficult to prove.

One of the most interesting chapters in the new story of whales was that referring to their embryos. It was shown by the comparison of pictures that the youngest forms of the whale are like those of a mammal, in fact, very like those of man, with head, small neck and fore and hind limbs, the latter of which disappear as the embryo grows older. The nose and mouth openings are near together, the nasal hole traveling as the embryo develops to the top of the head in the whale. The speaker relies in part upon this similarity in the embryos for his statement that whales are descended from land mammals and give evidence of the great difference between these embryos and those of fishes. He also disputed energetically all hypotheses which seek to place the origin of whales among the now extinct saurians. The discovery that whales have hairs, which is one that Doctor Kuekenthal has made, makes it the more evident that they are descended from land mammals because the hair is a mammalian characteristic. In some of the embryos there is evidence of a mustache, in others of the grown whales a beard of about one hundred and fifty hairs has been noted, while in other species hairs on the head number about as many. This makes it out of the question to term this a hairless animal.

Why some other animals living in the water, the sea otter and the seal, have not lost their hair, but on the contrary have developed most beautiful fur, was explained by the speaker as due to the fact that these creatures are not yet fully adapted to the water, and since they pass much of the time on rocks or on ice, the fur has become necessary. In the place of the hair, the whale has developed an interesting heat retainer, a layer of blubber, filled with oil, that envelops the whole body beneath the skin.

Professor Kuekenthal assembled an enormous amount of information in his three lectures. He noted that in some species the hairs, which by the way are the highest development, the tactile hairs, have altogether disappeared and in place of them there are what may be sense organs susceptible to pressure. In some such way, the adaptation of these to pressure, the speaker accounts for the unanimity with which whales will dive, remain under water and rise again, though so far distant from one another that vision between them is out of the question. Whale meat is good to eat, but being close to the blubber which is filled with oil it must be thoroughly separated from this to be palatable. The question was raised whether whales sleep. There are a number of theoretical reasons which have been urged in the negative. A whale has been known to follow a steamer in the South Atlantic for twenty-four days, during which time it could not have slept. Some French naturalists argue against the possibility of the whale maintaining its balance in the water if asleep. On the other hand the *Deutschland* killed a whale by collision with it and it is asserted that this one was asleep, while Professor Kuekenthal reported to science that he had observed the white whale asleep. The speaker believes in the sleep of whales and thinks that there may be some automatic action which gives the animal way enough to keep it in equilibrium. In this as in many other matters observations are necessary. These must be made quickly now or the opportunity will be lost, for the extinction of the whale is at hand unless some international legislation is instituted to regulate the matter of its capture.

One of the items that this authority set right was the so-called spouting of whales. Almost since time immemorial the idea has prevailed that whales spout

Sulphur bottom whale spouting; Placentia Bay, N. F., Sept., 1903

water through their blow-holes, and even recent text-books carry along the fiction. What has been taken for fountains of water by sailors and others is in reality the breath of the whale charged with moisture. It may be likened to the visible breath of a man on a frosty morning. The reason that it is visible is still something of a puzzle. The lecturer suggested that the breath of the whale is sent out from the lungs under powerful pressure and the expansion of it as it reaches the free air induces cold which makes the vapor visible. The fact that young whales do not blow nor do the larger ones on hot days, seems to support this suggestion. An excellent picture from the collection of Glover Allen, secretary of the Boston Society of Natural History, is very suggestive of the latter hypothesis and shows how different from a column of water the true spouting really is.

Incidental to this statement there was quite an exposition of the mouth and nasal anatomy. The blow-holes connect with the lungs directly and there are water-tight muscular rings at the point of crossing of the gullet. The mouth has no real connection with the nasal passages, so that it is impossible for the water taken in at the mouth to be thrown out at the blow-holes.

There are a number of different arrangements of blow-holes; some whales have two that are distinct, while in others the holes unite just at the skin, so that these whales can spout but one stream. The holes are set at different angles, so that one skilled in the whaling profession may identify the species by the character of the spoutings.

Another interesting question was with reference to the diving of whales. The motion was shown, the whale curving its body, pointing its head directly down

and oftentimes going so directly in the vertical that the flukes of the tail rise above the surface of the water. The depth is subject to some uncertainty on account of the difficulty of observation. There are examples in which the line to the length of 3,000 feet has been taken by the whale in a dive after being struck, the evidence being that the creature swam directly down, coming up later in the same place where it had disappeared. The sperm whale does not go so deep, but in 800 feet of water it is said that one ran against the bottom so hard as to plunge his head into the mud.

The creature that goes to the depth of two or three thousand feet in the water is subjected to enormous pressure, at the latter depth the lecturer said being equivalent to about a ton per square inch of surface. It is natural, therefore, to expect special devices fitted for this pressure. The most remarkable of these is the supplying of blood to the brain, not by the carotid artery, but by a special one which finds its place in the outer coating of the spinal cord within the spinal column. The eyeball is also adapted to extreme pressure, being as solid almost as a cannon ball. Then there are other devices like valves for the apertures which fit the animal for deep diving. Evidence points to the fact that the old fossil whales were deep divers also.

In point of feeding whales may be divided much like land animals into pasturing and predacious. The grazing animals are not strictly herbivorous, however, as on land, for although there are enormous quantities of the microscopic plants on the surface where the whale feeds, there are also small crustaceans and other fleshy animals. The mouth is opened and enormous quantities of water enter it. The mouth may be as long as fifteen or twenty feet, so that a boat could float in it and the roof is high in some species, the whalebone whales having there the great plates of whalebone whose ragged edges form the filter in which the organisms catch. When the mouth is closing the water is spurted out, the fauna and flora being caught by the filter, and the tongue crushes them and they glide into the gullet. There is in this connection a curious adaptation in which the furrows of the lower side of the head figure. The tongue is a great mass of muscle about as long as the mouth, but when the mouth is opened the tongue has disappeared. It is in reality forced into the floor of the mouth, pushing down and distending the muscles of the lower jaw. The furrows make the skin elastic, so that it can accommodate the extra material.

The time of whales' remaining under the water between breathings was given as different in different species, from 5 to 20 minutes in the small species and as high as an hour and three quarters in the larger ones.

UNKNOWN PHENOMENA OF MAGNETISM

Several unexplored phenomena of magnetism are referred to in a paper by Doctor Steinmetz recently presented before the Franklin Institute. One relates to permanent magnetism and involves an answer to the question, What is permanent in the permanent magnet—the magnetic flux, the mmf, the flux density or distribution, or the magnetic energy? Again, there is no satisfactory explanation of hysteresis—that is, of the loss of energy by a cyclic change of magnetism. Finally, the Heussler and other similar alloys have introduced problems that require elucidation and the magnetic characteristics of oxygen should be studied.

COST OF GOOD ROADS

Mr. Logan Waller Page, director of the United States Office of Public Roads, is authority for the statement that $1,000,000 a day was expended on road construction and maintenance in the United States in 1910; the amount spent in 1904 was $80,000,000 and it was estimated that $140,000,000 was spent last year, which is an increase of 75 per cent. in seven years.

SAFEGUARDING WHOLESOME FOOD

WHAT THE ENFORCEMENT OF THE PURE FOOD LAW INVOLVES—HOW SYSTEMATIC RESEARCH IS MAKING FOOD SUPPLIES BETTER AND CHEAPER

BY A. G. WOODMAN

The enforcement of the Pure Food Law is ordinarily regarded as consisting almost entirely in the collection and analysis of samples of food and drugs and in the prosecution of offenders in the courts. One who has not made a rather close study of the workings of the Federal Act and its various applications can hardly realize the amount of work in other lines that is involved and the numerous ramifications into which the activities of the officials must be carried.

Too often we hear it said by unthinking individuals that the Pure Food Law has been a "failure." Even those whose actual dealing with trade conditions in food and drugs ought to give them a clear knowledge of the true state of affairs will say the same thing, pointing out, it may be, specific instances in which the "law is not strict enough" or in which certain lines of business are unduly hampered or restricted.

I have no intention or desire to appear in the rôle of apologist for the shortcomings of the present law; it is admitted by its friends that it has not accomplished all that was expected of it. Whether this is due to opposition on the part of certain manufacturing interests, such opposition not appearing openly but disguised in many cases as an attempt to improve the working of the law by innocent amendments proposed ostensibly in the interests of pure food; whether it is due to the reading into the law of referee boards that were certainly not contemplated by the framers of the Act; whether it is due to the emasculation of its powers in certain very desirable directions by Supreme Court decisions; it is not proposed to discuss here.

It must be evident to all that radical changes in present conditions of manufacturing and handling foods, desirable as such changes may be from a theoretical standpoint, cannot be instituted without seriously interfering with the business of manufacturers. Such a balance must be maintained between the conflicting interests as will give the best results viewed from all angles, and action should be taken only after due consideration and careful study of each problem.

In order to do this many investigations have to be carried out under diverse conditions and I wish to speak briefly of some of the questions which the enforcement of the food laws has involved directly or indirectly. A consideration of these can hardly fail to show that the subject is so extensive that it is very far from just to condemn the authorities if they fail to move in all directions with the rapidity that some critics would consider desirable.

Some Typical Examples

A typical example of the prolonged investigation which it has been necessary to make in the case of some foods is found in the studies on deterioration in poultry and eggs. This work began with a chemical and microscopical study of the changes which take place in the flesh of chickens in cold storage and has led to an investigation of the methods of handling poultry on a large scale in every stage from the producer to the consumer. It has necessitated the co-operation of merchants, raisers, railways, refrigerator-transportation companies and storage-warehousemen.

Large poultry packing establishments from Kansas to Iowa have been visited, the methods of killing, picking, chilling, packing and transportation observed, and carload lots traced and portions

examined from time to time during transit and in the storage-warehouse. The comparative advantages of drawn and undrawn poultry have been carefully studied on numerous shipments made in warm and in cold weather on a commercial scale, and thousands of analyses made to learn the chemical and bacteriological changes taking place.

Similar investigations have been made in the case of eggs. Eggs of known history, from those of the highest quality to those of the very lowest grades, have been analyzed and studied microscopically after keeping for various lengths of time. It has been necessary to establish small but complete laboratories at various packing centers in order that this study may be made on material gathered at first hand. This work alone has involved the carrying out of over 3,000 analyses.

In addition, much bacterio-chemical work has been done in studying the conditions of the oyster and clam industries. This included inspection of oyster beds, floats, shucking houses, containers and shipping and transportation conditions, and chemical and bacteriological examinations of the products handled. Similar work is being done in the case of mineral springs and bottling establishments. Conditions as regards proper sanitation are noted in factories and other places where food is prepared, such as milk depots, ice-cream factories, bakeries, candy kitchens, hotels, boats, dining-cars and the like.

The spoilage of cod and other salt fish has been studied by an inspector of the Bureau of Chemistry and a special bulletin has been issued on the subject as a result of his work. The specific organisms causing the spoilage have been determined and the conditions under which they increase have been investigated. This information is of immense value to the fish industry and will be of the first importance in improving the quality of the product marketed.

Another example of investigations made under the law of the conditions attending the shipping of food products is the study made of the practice of packing oranges and grapefruit while immature and by a sweating process in steam-heated chambers so changing the color as to simulate the ripe fruit and supply the Northern market in advance of the time of normal ripening. Fruit so treated is inferior to that normally ripened and not so wholesome. As a result of the examination of the material a decision of the Board of Food and Drug Inspection was issued forbidding the practice.

Improving Shipping and Handling

Furthermore, it has been necessary to carry out extended researches, not only into the shipping and handling of food products, but also into the methods and conditions of manufacture, in order to be of benefit to the manufacturers themselves, and also to demonstrate that the requirements of greater cleanliness and the preparation of a high grade product is not a hardship. An instance in point is the manufacture of bottled ketchup. Many laboratory and factory experiments have been made, in order to increase the length of time that the ketchup would keep without spoiling after being opened. It has been shown that ketchup can be prepared, on a large scale, without any added preservative, and have it keep indefinitely before opening and for a reasonable time after opening. Many analyses had to be made of ketchups on the market and methods elaborated by which to show the character of the materials entering into the manufacture of the commercial product and the care used in its preparation. The general appearance of the ketchup, and its taste, color, and smell, may be easily modified by a skilled manufacturer, but no amount of cooking or finishing can change the microscopical structure.

The same line of work was carried out to show the changes in composition taking place during the manufacture of cider vinegar. In co-operation with a large commercial plant tests were made at intervals on 20,000-gallon lots run through generators. Important data were obtained for fixing standards for pure cider vinegar, made necessary by new forms of sophistication. Elaborate

studies on the chemical composition of cider were carried out in the New York laboratory in this connection.

Special investigations that often mean an immense amount of work and extend over a long time are often demanded as the result of the analysis of samples obtained in the routine procedure or of information obtained by the inspectors in the regular examination of factories. The finding of arsenic in the coating of cheap candies sold to children led to a study of the occurrence of this dangerous element in various classes of food products, and the amount present in commercial samples together with the source from which it enters the material is being determined. Many products in which phosphoric acid or phosphates are used in the manufacture, such as syrups, baking powders, gelatin and jams, may have arsenic present in distinct amounts. Just how much is dangerous, and how much, if any, should be tolerated, is a matter that can be settled only after much study.

A thorough study is being made of a large variety of foods put up in tin, and known to be of standard quality. These are being examined from time to time in order to note any changes in the character of the contents and to determine the amount of tin which may be taken up from the can under different conditions.

Another case in point relates to the sale of flour bleached by the use of nitrogen peroxide. Exhaustive studies were necessary in order to show the effect of the bleaching process on the digestibility and wholesomeness of the flour before its manufacture and sale could be properly forbidden. A great amount of labor and time was expended in the preparation of the case on which the decision of the courts was obtained, as it was felt that this was a most important matter. The services of numerous inspectors and leading chemists in the department itself were necessary. Outside experts were secured, and the whole subject examined most exhaustively from the standpoint of physiology and biological chemistry.

Adulteration of Drugs

The subject of drugs forms an important branch of the work of enforcing the Food Law, a branch, moreover, which spreads and divides in many different directions. The officials are concerned with the manufacture of pure drugs and with the prevention of the sale of remedies which are calculated to deceive or defraud the purchaser, either through the character of the material itself or through misleading statements regarding the curative properties of the article.

Take the case, for instance, of the sale of certain essential oils. The manufacturers advertise that their salicylic acid and methyl salicylate, two largely used remedies for rheumatism and related diseases, are made from oil of wintergreen. Physicians have complained of late that those products did not give so good results in use as formerly. The matter came to the attention of the authorities and it was easily ascertained that the small amount of genuine oil of wintergreen produced in this country could not supply the source of all the material which was being sold as natural salicylates. It was found that it was made largely from the related compound, oil of sweet birch. This is not so good, but the substitution is very hard to detect. Studies are now in progress in the attempt to devise methods by which to detect oil of birch and artificial methyl salicylate in the oil of wintergreen.

The requirement under the law that the presence and amount of certain powerful drugs must be declared on the label has made it necessary to examine and improve the methods used for the separation of acetanilid and related substances used in headache powders, and this has been done with marked success.

The chemists under the Food Law also co-operate with the Post Office Department in obtaining fraud orders against medicinal agents represented as cures for various maladies sent or prescribed through the mail. Analysis of samples of the medicine must be supplemented by a study of all the claims and repre-

sentations made for the treatments. The number of remedies in each treatment varies from one to ten, all of which must be examined. Typical of these are the so-called "cancer eures" in numerous cases of which the Post Offiee Department has issued fraud orders, as a result of which the mail order "cancer eure" business has been largely suppressed in this eountry. Other cures whieh have been or are being investigated are for epilepsy, tuberculosis, vitality, eyesight restorers, all of fraudulent character.

Investigating "Cures"

Most of the epilepsy cures are sold by mail, although a few are in the open market. These are second only to the cancer cures in the misleading and deeeptive character of the claims made for them. They claim to eure epilepsy independent of its character or duration, absolutely and permanently. Representations are made that the epileptic seizures are less frequent through taking the medicine, the diseased condition of the brain is changed and diseased tissues of the brain are replaced. These claims are, of eourse, false and misleading in the highest degree. No substance is known in medicine which can replace old or wornout tissues in any part of the body by new. These remedies, by the use of drugs, palliate the severity of the seizures. The relief is temporary and the remedy is not a cure in any sense of the word.

Consumption cures are sold through the mails as well as in the drug stores. So far as can be learned as the result of much investigation and through medical testimony they are not cures; their effect is only temporary. Some, nevertheless, are represented as absolute cures for all forms of tuberculosis. A diagnosis on a blank form, in the absence of the patient, which forms the basis of these "cures," is practically worthless. It is true that millions of dollars are spent annually to prevent consumption, but there is no drug which is a specific for its treatment and the time and money spent on these remedies but delay the proper hygienic treatment which is essential.

Drug-addietion cures have also been given much attention during the past year. Numerous institutions engaged in the practice of treating those afflicted with the opium, morphine, or cocaine habit by furnishing a "treatment" with instructions have been "under fire." It is found, as a rule, that these "eures" eontain in large quantities the very drug for which they are being taken. They are sent with no warning as to their dangerous character, and by their use the habit is more firmly fixed upon the unfortunate sufferer. Some of those selling these preparations were found to be unaware of the eharacter of the treatment. It seems incredible that a dangerous drug of this kind should be sent out by a groceryman without any ehemieal or medical knowledge, but such was the case in one instance. He had purchased the business and simply mailed the treatments to anyone asking them. It is, of eourse, well known that these habits can be treated successfully only under careful supervision of a eompetent physieian and that the patient is entirely incapable of curing himself. The chief object of these treatments seems to be to extract money from the patients as long as they will respond. Cases are on record where the treatments were supplied for years. Each case of this kind has to be carefully looked into to see how it ean best be stopped.

A comparatively recent form of fraud, which reeeives attention under the Food Law, is the exploitation of so-called "prescription remedies." These usually call for several well-known medieinal agents, together with a coined-name product in the sale of which the advertiser is interested. In order to fill the prescription it is necessary to purchase the agent sold under the eoined name. For example, in the preparation of a face lotion, the patient is advised, by a paragraph in the "Beauty Column" of some newspaper, to purchase a cheap, well-known product under a fancy coined name, mix it at home with certain common household agents, among them water, and apply the resulting mixture. A typieal one of these, largely sold, con-

sists essentially of magnesium sulphate (Epsom salts), colored and perfumed. The actual cost of a fifty-cent package is not over one cent. Investigation shows these preparations in many cases to be unmitigated frauds.

Fraud in Imported Products

Careful examination and study must be made also of imported products for the presence and amount of harmful drugs. Importations from Oriental countries, ostensibly medicinal preparations, have been found to contain opium or morphine. These products are put up in various forms, as small red pills or tablets coated with cinnabar and wrapped in waxed paper, or in wax globules. They are invoiced under misleading names as "tonic pills," "stimulant pills," "tea cake," etc., and are recommended on the label for coughs, colds or consumption. The statement is sometimes made on the label that they are free from morphine, that they are "perfectly harmless" and "especially beneficial for women and children." Some of them, put up in the form of a pleasant confection, are a source of great danger when coming indiscriminately into the hands of mothers or children who are unaware of their harmful nature. Another preparation containing chloroform and ether, imported as a cough lozenge of value in coughs and colds, was found upon investigation to be sold to school children and others as a form of candy with no notification of the dangerous character of its ingredients. Such practices are of course prohibited, but their thorough investigation requires a great deal of time and labor.

Over one hundred brands of medicated soft drinks have been found upon investigation to contain large or small amounts of caffein and nearly a third of the number contained small quantities of cocaine. The amount of cocaine in each case was small to be sure, but the unrestricted sale of these beverages, often to children and younger people, can readily be seen to be a fruitful source of danger. Persons addicted to the use of these drinks are found to be factory employees, stenographers and others subjected to nervous strain, many spending a considerable proportion of their earnings in this way. Very small amounts of cocaine affect deleteriously the nervous system and the prevalence of the habit is shown by the fact that the large life-insurance companies are considering seriously the status of these soft-drink habitués as future risks.

Nor should the time devoted to inspection of food products be overlooked in a summary of the extent of work necessary, work which does not come directly before the public, but which is nevertheless essential. One or two examples chosen from imported foods will serve as illustrations.

The condition of the figs coming into this country has required much time and study. These figs have been found to be largely wormy or worm-eaten or infested with sugar mites. It has been necessary to pick over each shipment and sort out the figs containing live or dead worms, worm excreta, sugar mites and molds. In order to identify these a study had to be made of the history of the so-called worms, which were allowed to develop in sterile figs, the resulting moth laying her eggs, and the complete cycle was thus followed.

Olives imported in bulk have needed frequent and thorough inspection in order to exclude those of inferior quality, over 90 per cent. of those entering at a single port being found to be wormy and unfit for food.

A large number of shipments of beans from Italy were found to be infested with a small fly, the bite of which produced a rash on the workmen on the docks.

It is hardly necessary to multiply examples further. From what has been stated it will readily be appreciated that there is much work to be done in the enforcement of the Pure Food Law which does not appear on the surface. All these investigations which were in progress or brought to completion during the past year, were conducted in addition to the regular analyses which included many thousand samples. They probably do not represent a period of more than

normal activity in this respect, for new matters and trade practices requiring consideration are constantly demanding attention. The problem is certainly a large one and both time and patience on the part of officials and of the public are necessary if it is to be solved in the best way.

A DISSENTER FROM DARWIN

In the four Lowell lectures by Professor W. Johanssen of Copenhagen on "Primary Conceptions of Heredity," the speaker gave a low estimate of Darwin, referring continually to the mistakes in his hypothesis of selection. He was apparently set but little higher than Hippocrates, save that he knew of the circulation of the blood and could make use of it. In much the same way the speaker treated Galton, acknowledging that he has secured many statistics in work on humans and in botany and has formulated various ratios, which observation with large numbers has set aside. The text of the whole course of lectures was that personal characteristics are not transmitted from ancestors to progeny.

The subject is a technical one and Professor Johanssen did not present all of the links that a popular discussion might require. His general ground is that the traits of individuals are the results of certain combinations of factors in the egg and the sperm, termed gametes and when combined zygotes. The boy resembles his father not on account of his being his father, but because the same kind of gametes and zygotes dominated in his embryo. They are alike because they are similar products.

Galton made many researches with reference to size, but his conclusions that a certain ratio of large or little height, for example, will persist in the progeny has been overset by showing that in beans, for example, the combining of small sizes will not result in the end in a product always of small size.

The lecturer brought to the company two new words, "phenotype," looking alike, and "genotype," acting alike. Many individuals that look alike prove to have very different progeny, while others quite unlike in appearance are found to produce likes. The lecturer illustrated this point by saying that water and alcohol look alike but their effect is very different. Much of the lecturer's argument was in calling attention to chemical matters, and the speaker sought to point his moral with chemical reactions.

Professor Johanssen disposed of some of the terms used by students of heredity. He noted "dominant" characters are often not dominant, that "unit" characters are often complex, and warned his hearers with reference to the loose use of terms, saying that a boy does not inherit his father's taste for tobacco, but imitates it.

"Biotype" is another of the words, which describes the factor whose reactions shall be constant to a given type. But as in chemistry there are different forms to the same combination of elements—water, ice and steam, for example—so there is here what might be termed, "an elasticity," to the biotype. This elasticity, Professor Johanssen explained, is what is responsible for the variations from type forms. In connection with this there was urged the discontinuity of type. The trend at both ends was missing from this portion of the story. The suggestion was that the biotype is capable of so much elasticity that the different ones are able to cover all known forms. This idea is distinctly at variance with the one usually held by naturalists that the varieties in types are probably the remnants of old connecting links. The speaker rules out from the argument the evidence that a museum can adduce from its specimens, using for his illustration here the raindrops on the sidewalk. One might take scattered rain-

drops—the specimens in the museum—and make from them a story which would be at variance with that of the rain covering the whole sidewalk,—representative of the fullness of variety of Nature.

"Pure lines" is one of the specialties which this speaker brought forward, being so nearly as may be represented those species the zygotes of which are relatively such that the species breed true.

Incidental to the lectures were many references to illustrations, flowers, the lower animals and invertebrates and the like by which the points were illustrated. There were also many references to experimental work, which the speaker said all pointed to the fact that personal characteristics are not transmissible. One of the most interesting series noted was that by Tower of Chicago, who, in experimenting with the Colorado beetle, established some facts. With heat and moisture he changed both the adults and the eggs and young. While the living adults were changed in their markings their young exhibited the normal markings of the species. On the other hand the changes effected in the eggs proved constant. In some of the experiments an intermediate untreated laying of eggs bred true while the treated groups were alike different.

One of the practical outcomes of the study was the expression at the fourth and last lecture that eugenics is established on a false basis. "The individual," he said, "who in the midst of poor surroundings has become a criminal might, under better environment, have made a very fine man."

TESTING PROPELLERS

A CONCLUSION reached as a result of experiments conducted by the department of naval architecture of the Institute after two years of work with the model boat *Froude*, is of great interest. The Technology experimenters assert that propellers are seldom set in the proper place to get the highest efficiency. Professor Cecil H. Peabody says that placing the screw a couple of feet farther astern from the hull will oftentimes give an increase in efficiency of from 10 to 12 per cent.

REINFORCED CONCRETE SCOW

A SCOW to be used as a tender for supplying coal and fresh water to river dredges has recently been built of reinforced concrete for a firm at Baltimore, Md. The vessel is 80 feet long, 22 feet wide and 7 feet deep, the walls being 3 inches thick. Two bulkheads, each three inches thick, extending the full length of the scow, form the water tanks. The scow has a capacity of eighty-seven tons. As an acceptance test, a mass of material weighing over six tons was dumped into the hold, but no signs of failure occurred.

NEW MEMBERS OF THE SOCIETY OF ARTS

AT THE 676th meeting of the Society of Arts held Monday, January 22, the following applicants for membership were presented and elected:

GEN. FRANCIS HENRY APPLETON, 251 Marlborough St., Boston.
E. F. AYER, 141 Milk St., Boston.
WILLIAM SUMNER APPLETON, 8 Park St., Boston.
GEORGE S. BALDWIN, 27 State St., Boston.
ALBERT G. BARBER, 403 Washington St., Boston.
ARTHUR L. COLLIER, 26 Baker Ave., Beverly, Mass.
CHARLES K. CRANE, Dalton, Mass.
HENRY E. DARLING, 15 Dey St., New York, N. Y.
J. WINSOR DAVY, 301 Equitable Bldg., Boston.
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THE PRINCIPLE OF RELATIVITY

THE NEW IDEAS OF SPACE AND TIME WHICH HAVE MARKED AN EPOCH IN THE MODERN THEORY OF PHYSICAL PHENOMENA

BY D. F. COMSTOCK

II

In the last article it was necessary to deal with the Principle of Relativity in a general and somewhat vague way. In the present article a more definite treatment will be attempted.

The Principle of Relativity came into existence through the study of "electric systems." By an electric system is meant a combination of electrically charged bodies having any shape and moving in any way. It will be remembered by those who have studied elementary physics that two electric charges of the same sign repel each other, while two charges of opposite sign, attract each other. Any group of charged bodies is, therefore, acted upon by numerous forces throughout its structure. According to the particular structure of the system, these forces may tend to elongate, compress, twist, or deform the system in any way, dependent, as has been said on the particular position of the electric charges and on their magnitude.

Now there are certain fundamental facts which seem to indicate clearly that the atoms of matter are to be considered as electric systems, and consequently the above remarks with regard to electric systems in general apply with force to all considerations respecting the constitution of the atom.

As a matter of fact, the forces above referred to, which must exist throughout any system of electric charges are probably all of much greater importance in atomic phenomena than they would be in the case of any electric system which we could construct in our laboratory, for a reason which may be briefly outlined as follows: When a metal conductor is charged with electricity and, therefore, becomes one example of an electric system in the above sense, the forces due to its charge tend to distort it in one way or another. But in the case of any charge which we could hope to communicate to the conductor in the laboratory, these forces would be so extremely small compared with the rigidity of the metal, that in general there would be no change in shape which could be noticed with ordinary instruments.

We have every reason to believe, however, that the case is very different indeed with an atom considered as an electric system, for as will be remembered by those who have followed the development of modern physics, the atom must be considered as composed largely of minute charged particles called *electrons*. These particles are so much smaller than the atom that the size ratio might well be illustrated as that of a pin head to an office building. We know very little about the actual structure of the atom, very little, that is, of the way in which the contained electrons are arranged within it, but there seems to be good reason for believing that there is *some* definite arrangement and that a number of electrons, together with a certain amount of the even more mysterious "positive electricity," go to make up the thing which we call an atom of matter.

Now the "unoccupied space" within the atom must apparently be very great so that the electrons, held in some sort of equilibrium by the electric forces, must be very far apart compared with their size, and hence an atom considered as an electric system is quite a different thing from the charged conductor in the laboratory; for if all the electric charges on the conductor were doubled, the electric forces would be greatly increased,

but as was indicated above, there would be no appreciable change in shape, whereas,—and this is important,—if we imagine the charges on all the electrons within the atom to be doubled, it is probable that the atom would immediately assume quite a different shape. The principal forces within the atom are electric,—the principal forces of our metal conductor, are not the electric forces we have set up by charging but the so-called "forces of rigidity" which give a solid body its permanent shape.*

Now since we may consider any piece of matter whatever, from the physical point of view, as simply a combination of an enormous number of atoms, we may make the following condensed statement: *A piece of matter is probably a complex electric system, being ultimately far more porous than our senses would lead us to suppose. The volume it occupies, its shape, and its tensile strength are probably in the last analysis determined by the number, magnitude and arrangement of the electric charges which it contains.*†

A further complexity now arises which, however, is very important for all "electric systems," and particularly for the type of system which we have supposed the atom to be, for all the electric forces above discussed are somewhat modified when the electric system is set in motion. This is largely due to two facts, long known in the science of electricity;—first, an electric charge in motion acts like an electric current and, therefore, sets up a magnetic field (*i. e.*, magnetism) around it, and second, an electric charge moving through a magnetic field is acted upon by a force which forces it "sideways."‡ In the case of the electric current, which the moving charge imitates, these two effects are well known in electrical engineering and are at the foundation of the operation of every electric motor. The magnetic field of a motor is produced through the first effect and the lateral thrust on the wires in this magnetic field, which causes the armature to turn, is the result of the second effect.

An electric system set in motion is therefore acted upon by new electric forces caused by the motion, for each charge on the one hand sets up a magnetic field around it due to its motion, and on the other hand is acted upon by forces due to the fact that it is moving through the magnetic fields of the other moving charges. The shape of the electric system, therefore, will be changed if it is set in motion, almost infinitesimally in the case of the small charges which we put on objects,—but quite appreciably if we look at any piece of matter from the point of view of its ultimate atomic structure and the electric nature of the atom.

The exact nature of the change in shape may be calculated from the above mentioned well-known electrical laws without any further assumption. As a matter of fact it can be shown that the new forces are such that the *whole system tends to contract along the line of motion.* It may also be shown that if any charge is oscillating back and forth in a stationary system, *it will oscillate a little more slowly in the same system moving.*

On grounds of well-established electric theory and without any new fundamental conceptions whatever, we may therefore make the general statement. *Any electric system, when set in motion tends to assume a new state of equilibrium, and if this change be allowed to take place then all effects take place in the changed system in a manner exactly corresponding to the way they did take place before the system was set in motion,* all lengths in the direction of motion being a little shorter, however, and all times a little longer.

Looked at from the present point of view, the ultimate question is,—*Can a piece of matter be considered as an electric system?* We have said that there are

*Since the conductor is made up of atoms, these forces of rigidity are in the last analysis atomic forces, and therefore, also electric, but it will be clear that we are thinking of the metal conductor only in relation to the charge *which we put on*, and not with reference to the charges of electrons within it.

†If this statement is not strictly true, it is at least true in part, for whatever non-electrical forces may later be found to exist, it is almost certain that electrical forces play a large part in the phenomena.

‡That is in a direction perpendicular to its velocity and to the direction of the field.

many reasons for believing it can, many more reasons in fact than can be mentioned in an article of this kind.

Considerable light can be thrown on this question by thinking of the earth as a vast moving system traveling as it does around the sun. Let us see what differences we would notice, if we consider first, the earth stationary in space which is easily thinkable, and second, the earth traveling, as it actually does, around the sun with a speed of about 18 miles a second. In the first case, we would be on a stationary electric system,—in the second case, we are on a rapidly moving electric system. What differences would we notice? A little thought will show that unless we observe other planets and stars we would notice *no difference whatever*, for since *all* our lengths are shortened alike in the direction of motion, and *all* our clocks, for they too are electric systems, run a little slower, the relations, which after all are all that we really observe, would remain exactly the same. If I measured a wire on the stationary earth and then again the same wire after the earth has been set in motion I can only do it with another piece of matter called a yard stick and, as all electric systems act alike, I would get the same result in both cases. That is, if the yard stick went five times into the length of the wire before the earth was set in motion it would go five times into the length of the wire after the earth was set in motion, although both lengths considered from the standpoint of the permanently "stationary" observer are shorter than before.

A like remark applies to all periodic happenings which we desire to time with a watch or clock. A "permanently stationary" observer would say that all such events on the moving earth took place a little slower than on the stationary earth, but if we found that while the earth was stationary, a certain pendulum beat four times a second, that is, beat four times while our clock was beating once, we would find exactly the same relation holding after the earth were set in motion, for our clock as well as the pendulum would then beat slower.

It is very important to realize while thinking of all time and space measurements that all such measurements are ultimately *ratios* and nothing else. This fact we are all inclined to overlook. When we say that a certain event requires just *ten* seconds, we can know the *precise* meaning of the statement only when we refer to the definition of "a second." Now "a second" is defined as $\frac{1}{86400}$ part of the "mean solar day," and the "mean solar day" is the average time that it takes the earth to turn once on its axis with respect to the sun, so that ten seconds is simply $\frac{1}{8640}$ of an "earth turn." If every speed we know were suddenly doubled all time measurement would be exactly the same as now.

Although it would not be wise to enter here into a discussion of the evidence for believing that a piece of matter may be treated as an electric system, it will be well to mention one very striking result which is very closely connected with what we have just been saying. For if the discussion outlined above is true, we should not be able to detect the earth's motion through space by experiments carried out *on the earth*, that is, without appeal to an outside body, whereas, from almost any other point of view than what I might call the electric system one, effects due to the earth's motion through space should be easily detected.*

Now as a matter of fact, numerous, carefully planned experiments have been carried out to detect the earth's motion in space without reference to an outside body and every one of them has given negative results. The presumption is, therefore, strong from this evidence alone, that we are on the right track. *The necessary conclusion seems to be that all physical phenomena obey the same physical laws of which the known electrical laws are as yet the completest expression.*

Now it should be noted carefully that the reasoning which has been outlined above does not involve the fundamental

*We are, of course, referring to the motion of the earth in its orbit, not its daily rotation. This latter is very small compared with the former, and may be neglected.

conceptions of space and time in any new way. The result involves only well-known electrical laws and the assumption as to the ultimate nature of matter.

Besides the lengths and times on a moving system it can be shown that all the inertias change also. They become in a moving system a little greater than in the same system at rest. By inertia is meant, of course, the ordinary mass of a body, the measure of the amount of matter present. We come, therefore, to the conclusion that if a piece of matter can legitimately be considered as an electric system, then, whether a piece of matter is an atom or a planet, it will, when set in motion, have all its times, all its masses and all of its lengths in the direction of the motion changed somewhat, but *all relations* will remain the same as before.

To get the full implication of this, let us recall the definitions of the units of length, mass and time which men legalize and use in the practical world. Briefly indicated the yard is defined as a length of a certain rod kept at Washington; a pound is the weight (closely related to mass) of a certain piece of metal kept at Washington and the second is $\frac{1}{86400}$ part of an average "earth turn" (with respect to the sun). These units obviously are not abstractions but are determined by real objects, viz., a rod, a cylinder of metal and the planet on which we live.

Now from the standpoint of the "permanently stationary" observer, the three units, yard, pound and second, defined as above, are all different on a moving earth than they would be on a stationary earth. Moreover, they would be different still if the earth's speed in its orbit were to become greater than it is now, so that we can legitimately put our former statement into a somewhat more abstract form. *If all matter obeys the general electrical laws which we have experimental reason for believing that it does, then the fundamental units of mass, length and time are all different on a moving system than they are on the same system at rest.*

The magnitude of the changes in the fundamental units due to motion, is not difficult to calculate. As was said in the first article, the changes are far too small to be of what is generally called "practical importance." Their chief bearing is on electrical theory. The following brief table indicates in a general way the magnitudes involved.

Speed in miles per second.	*Decrease in length.*	*Increase in mass.*	*Increase in time of any motion on moving system.*
$\frac{1}{2}$ (Rifle bullet).	A million millionth of one per cent.	Same.	Same.
18 (Earth going around the sun.)	Five ten millionths of one per cent. (within reach of experiment using light rays.)	Same.	Same.
18,000 ("Alpha particle" from radium.)	Half of one per cent.	Same.	Same.
180,000 ("Beta particle from radium.")	Fifty per cent.	One hundred per cent. (measured and accurately verified.)	Same.

Although so extremely small, modern physics knows a number of experimental results which would be noticeably different were it not for these effects, and it therefore has opportunity to verify and study experimentally these fundamental changes.

Of course, it is always possible that some experimental result may turn up which would contradict the general principles here outlined and show that some different, although necessarily similar reasoning must be adopted. This, however, is a general statement which applies to any scientific result and not peculiarly to the present one. As a matter of fact experimental and mathematical research piling up, as it does, year after year has caused the belief to grow steadily that the new ideas are essentially in harmony with reality.

As has been said their chief scientific value is in the domain of fundamental electrical and optical theory where they harmonize much that before was chaotic.

The more or less heated controversy which the "Principle of Relativity" has started is, however, due to its more philosophical aspect. It is more or less generally admitted that the "change in units" above described takes place, but the thinkers who have had most to do with

modern electrical theory maintain that, since a moving observer is totally unable to detect in any way the changes in his system which a stationary observer declares do take place, and since, as can be shown, the moving observer sees exactly the same apparent changes in the units of the stationary observer as the latter sees in his, there is no possible reason for saying that one is "stationary" any more than the other.

This complete symmetry between the states of each observer, because of which *either* observer may be called "stationary" and the other "in motion," renders it impossible, these thinkers say, to talk logically about any length as *the* length or any time as *the* time. *Length and time are relative and depend entirely on the point of view, depend, that is, on the state of motion of the observer who wishes to make measurement.*

The conservative forces of the opposition, which, with rare exceptions, are recruited from those who have given the subject little thought, stoutly maintain that although it is impossible, because of the relativity of motion, to specify the time of one observer as any more entitled to the designation of *the* time than that of any other, still "time is one of our primitive intuitions, and must be thought of as universal and absolute." They would consider the fundamental changes which we have discussed as purely physical effects, like the expanding of a piece of metal by heat, and would consider our inability to tell which observer is "absolutely stationary" as merely a physical limitation due to the peculiar structure of matter and the nature of human activity. They think, therefore, that there is no necessity for the scientist and philosopher to reconsider his fundamental concepts.

As above mentioned, there has been a great deal of discussion on this queston during the last few years but the *a priori* arguments of the opposition are not heard as much as formerly and it is becoming increasingly probable that if the Principle of Relativity is finally discarded it will be through some newly discovered experimental fact and not through these *a priori* arguments as to its essential unreasonableness.

Definition

The "Principle of Relativity" is the name given to a group of conceptions founded on the apparently verified truths that, first, the uniform translatory motion of any system cannot be detected by an observer traveling with the system and making experiments on it alone, and second, the velocity of light is independent of the relative velocity of the source of light and observer. These two statements are more definite and exact, but they are nevertheless equivalent to the general statement that matter in general obeys the "electrical laws" in the sense above described.

The conclusion reached is that space, time and mass are all relative and depend on the motion of the observer, in a certain way definitely expressible by mathematical formulæ.

GROWTH OF ELECTRIC SMELTING

The Department of Mines of the Canadian Government has been investigating the smelting of iron by means of electricity. In 1904 when the investigation began there were only four of these electric furnaces in existence. In 1910 there were 114 furnaces, of which sixty-seven were in operation, eleven not working and thirty-six in course of erection. Of these furnaces thirty were in Germany, twenty-three in France, twelve in Italy, ten in Austria and ten in the United States. Seventy-seven of them were of the arc type, fifty-five were induction furnaces and two a combination of arc and resistance furnaces. A great increase in the output rating of the furnaces is noted, the largest at present in operation having a rated output of 15 metric tons per day.

The new wireless station at the Charlestown Navy Yard, Boston, has a maximum range under favorable conditions of about 3200 miles, thus making it among the most powerful in the world. The aërial poles will each be 170 feet high.

POTASH SOURCES IN THE UNITED STATES

INCREASING DEMAND HAS TURNED ATTENTION TO OUR POSSIBLE RESOURCES—LAKE BEDS SIMILAR IN FORMATION TO POTASH DEPOSITS IN GERMANY

BY G. F. LOUGHLIN

The recent tariff troubles between the United States and Germany have brought the potash industry to the attention of the public, and stimulated the publication of several articles on the potash industries and the possible potash resources of this country. The data for these articles is largely taken from United States Geological Survey publications, the most recent of which was written by W. C. Phalen, a Technology graduate (S. B. in chemistry '99, M. S. in geology '02).*

Mr. Phalen's paper gives condensed tables of statistics of the potash industry from 1850 to 1910. The figures show a steady decline of domestic potash production from a value of $1,401,533 in 1850, to $104,655 in 1905, since when, practically all the potash used in this country has been imported from Germany. The value of potash salts imported in 1910 was $8,363,623, an increase of 51.45 per cent. over the value in 1905. He also gives statistics of chemical manufactures in the United States dependent on imported potash salts, and gives some mention of their processes of manufacture, including potassium carbonate, caustic potash, alums, cyanides and derived compounds, fertilizers, bleaching materials, dyestuffs and explosives. The remainder of his paper includes a brief review of the occurrence and mining of potash in Germany, and of the known and possible sources in the United States including mineral deposits and the organic sources, wood ashes, beet-sugar molasses, and residues, wool scourings, and potash in seaweeds.

Potash in Seaweed

One most valuable result of the controversy with Germany was the appropriation by Congress of a limited sum for the investigation of the potash resources of this country. The investigations have been undertaken by the United States Department of Agriculture and by the United States Geological Survey. Secretary of Agriculture Wilson has presented the results of his inquiry in his recent annual report. He states that much potash can be recovered from the immense accumulations of sawdust in lumbering regions, and from other sources already mentioned, but that the most promising source at present is found in the large areas of kelp groves or sea algæ along the Pacific coast. These groves are of various areas, some attaining a length of 5 miles and a width of 2 miles. During the past summer about 100 square miles of kelp groves were mapped and studied and many more areas yet remain unmapped. A conservative estimate shows that the kelp which could be gathered from the 100 square miles already surveyed, and without detriment to the permanence of the groves, should yield 1,000,000 tons of chloride of potash annually, worth at least $35,000,000 or about thrice the value of the present importations from Germany.† The value of the kelp is increased by its content of iodine and probably other useful products which are expected to pay in large measure, if not fully, the cost of gathering the kelp and extracting the potash salts. Methods for gathering the kelp have yet to be worked out, but "enough has been

*Phalen, W. C. Potash Salts, their Uses and Occurrence in the United States. U. S. Geol. Survey, Adv. chap. from Min. Resources of U. S. for 1910, 24 pp. Washington, D. C., 1911.

†Quoted in the *Engineering and Mining Journal*, Dec. 9, 1911.

accomplished to show that this country has within its own borders resources to meet the fertilizer requirements of the present, and of a greatly increased use in coming years."

Potash in Rocks and Minerals

No results of the United States Geological Survey's work have yet been made public, notwithstanding various reports of wonderful discoveries announced in the daily press. The Survey's operations have consisted chiefly in prospecting localities where geologic conditions give the most promising hopes of finding natural potash salts—the beds of extinct salt lakes in the arid west. Some private companies also have been prospecting these deposits, while others are experimenting with the extraction of potash from certain minerals.

The ultimate source of potash, as of all the elements, lies in the igneous rocks of the earth—the lavas poured forth by volcanoes, and the far greater masses of the same material which consolidate at depth and become exposed to view only after prolonged erosion of the overlying portions of the earth's crust. These rocks include a number of different chemical compositions the most common of which contain potash in the following amounts:*

Deep-seated rocks.—syenite 4.49 %, granite 4.07%, diorite 2.12%, gabbro .89%. Corresponding surface lavas.—trachyte 5.74%, rhyolite 4.03%, andesite 2.04%, basalt 1.52%.

A few rocks of very rare occurrence contain over 10 per cent. potash; others, of widely distributed occurrence but in masses of very limited size, contain almost none. The percentage in the whole earth's crust, including the igneous rocks and other rocks derived from them, as estimated by Clarke† and others is about 3.00.

These rocks, save certain lavas which cooled rapidly to rockglass, are composed of definite minerals, a few of which contain important amounts of potash. The most common of these minerals are the alkalic feldspars with from 8 to 15 per cent. potash, black mica 6 to 9.3 per cent. and white mica 8 to 10.5 per cent. The rare mineral leucite contains as high as 19.5 per cent., while other common minerals such as the soda-lime feldspars and certain amphiboles contain small amounts.‡

These minerals and also the mineral alunite, a hydrous sulphate of potash and alumina (K_2O 11.4 per cent.) occasionally found in altered rocks, are possible sources of potash, but no process for its extraction from these minerals has yet been put on a commercial basis. Dr. A. S. Cushman, formerly chemist and assistant director of the Office of Public Roads, has taken out a patent for the extraction of potash from rock powders.§ It is also reported that companies have been formed to attempt its extraction from certain unusual rocks composed largely of leucite, in Wyoming, and from vein deposits of alunite near Marysvale, Utah, and at Goldfield, Nevada. At Goldfield, alunite is one of the most abundant minerals in the rich gold deposits.

Natural Concentration of Potash Salts

Wherever rocks are exposed at the earth's surface they are slowly broken up and worn away by the mechanical and chemical action of the atmosphere and of running water. Only the chemical processes are of interest at present. Of the common potash minerals named above, the alkalic feldspar and especially white mica are much more resistant to the chemical attack of the weather than most other rock-forming minerals; but with sufficient time, and under favorable climatic conditions, these minerals are slowly decomposed, the potash passing into solution, leaving a residue of kaolin

* Daly, R. A. Average Chemical Composition of Igneous Rocks. *Proc. Amer. Acad. of Arts and Sci.*, Vol. XLV. No. 7, 1910.

† Clarke, F. W. Bull. U. S. Geol. Survey, No. 419, 1910, pp. 4–9.

‡ Figures taken from F. W. Clarke, op. cit. pp. 257 *et seq.*

§ Published in the *Chem. Engineer*, vol. 5, 1907, p. 21; Bur. Census, Bull. 92, 1908, p. 39.

(china clay) and quartz. The dissolved potash with the materials dissolved from other minerals, comes to the surface in springs, becomes a constituent of river water and is carried eventually to the ocean, or, in arid regions, to some interior sea or salt lake. River waters differ considerably in their dissolved contents, owing to a number of causes, but their average potassium content is not far from the values in the following analyses which are fairly representative * of rivers draining areas of igneous rocks, or other rocks similar to the igneous in composition.

	1	2	3
Carbonate radicle (CO_3)	26.83	28.15	36.25
Sulphate radicle (SO_4)	14.46	12.78	3.19
Chlorine (Cl)	13.83	8.78	1.24
Calcium (Ca)	14.94	17.14	16.22
Magnesium (Mg)	1.80	4.18	3.25
Sodium (Na)	12.79	6.16	3.91
Potassium (K)	4.29	trace	2.25
Silica (SiO_2)	9.69	18.14	33.69
Alumina (Al_2O_3)	1.38	1.34	
Ferric oxide (Fe_2O_3)	1.38	1.34	
	100.00	100.00	100.00
Salinity, parts per million	14.5	170.	61.

1. Moosehead Lake, Maine.
2. Merrimack River, above Concord, New Hampshire.
3. Ottawa River at St. Anne, near the head of Montreal Island.

Glauconite (Greensand)

When this material reaches the ocean the greater part of the carbonate radicle (CO_3) calcium (Ca), and silica (SiO_2) is appropriated by marine animals. Much of the potassium is adsorbed by mud carried by rivers, a part is taken by plants, for example the kelp so abundant along the Pacific coast, and a part perhaps by the mineral glauconite, a hydrous silicate of iron and potassium (K_2O 3.5 to 9 per cent.), which is now being deposited over a wide area in the shallower waters of the sea just beyond the limits of wave and current action. The process of the deposition of glauconite, however, is complicated and it is very probable that the source of its potassium is in fine particles of undecomposed feldspar in the mud,† or in the adsorbed potash just mentioned.

Such accumulations of glauconite, if later elevated above sea level, are of value as fertilizers. The greensand marls of southern New Jersey and Virginia consist of glauconite mixed with phosphate of lime (of similar origin) and other matter, and has been of incalculable value to agriculture in the first-named state;‡ but it has, in recent years been largely supplanted by the more highly concentrated artificial fertilizers.§

Analyses of the New Jersey greensand show from 3.53 to 6.32 per cent. potash and from 1.02 to 3.87 per cent. phosphoric acid. Glauconite is formed in other ways, but not in commercial quantities.

Potassium in Ocean and Salt Lake Waters

These losses of carbonate radicle, calcium, silica, and potassium through the many ages of geologic time have given the salts dissolved in ocean water quite a different chemical character from those dissolved in the average river water, as shown in column 1 below by the mean of 77 analyses of sea water from many localities by W. Dittmar.

	1	2	3	4	5
Chlorine (Cl)	55.292	55.99	65.81	67.30	23.34
Bromine (Br)	.188	trace	2.37	2.72	——
Sul. radicle (SO_4)	7.692	6.57	.31	.24	12.86
Car. radicle (CO_3)	.207	——	trace	trace	23.42
Bor. radicle (B_4O_7)	——	——	——	——	.32
Sodium (Na)	30.593	33.15	11.65	5.50	37.93
Potassium (K)	1.106	1.60	1.85	1.68	1.85
Calcium (Ca)	1.197	.17	4.73	6.64	.04
Magnesium (Mg)	3.725	2.52	13.28	15.92	.10
Silica (SiO_2)	——	——	——	——	.14
	100.000	100.00	100.00	100.00	100.00
Salinity	3.301–3.737%	14.994	19.215	25.998	5.117

1. Mean of 77 analyses of sea water. Clarke op. cit. p. 95.
2. Great Salt Lake, Clarke op. cit. p. 119.
3. Dead Sea, surface water. Clarke op. cit. p. 129.
4. Dead Sea, at depth of 300 meters. Clarke op. cit. p. 129.
5. Mono Lake, Cal. Clarke op. cit. p. 124.

*Selected from F. W. Clarke's Data of Geochemistry, Bull. U. S. Geol. Survey, No. 330, 1908, pp. 61 *et seq.*

†Clarke, F. W. Op. cit. p. 105.

‡Ann. Rept. State Geologist of N. J., 1886.

§Phalen, W. C. Op. cit. p. 18.

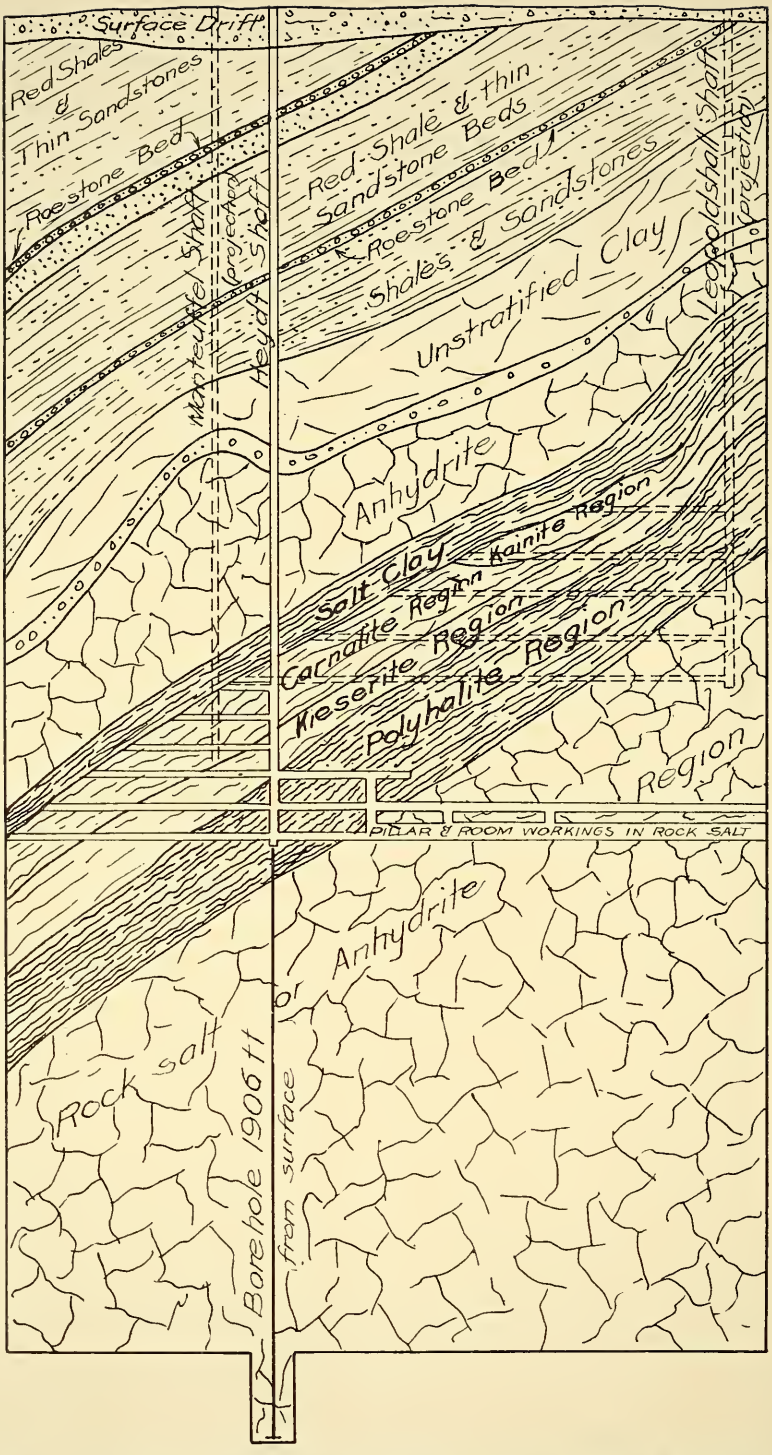

Fig. 1. Section of the Salt Deposits at Stassfurt. (From the Trans. Edinburgh Geol. Soc. V, 1884, p. 111.)

If an arm of the ocean is connected with it by a shallow strait, or if, by any means, a portion of the sea becomes isolated, and in either case the climate is sufficiently arid, evaporation occurs until saturation takes place and salts are deposited in a definite succession. Such conditions have evidently existed in the past, and exist at present, where recent elevations of land have separated the Caspian, Aral, and Dead Seas from the Mediterrancan. Kara Boghaz Gulf of the Caspian Sea, connected with it by a shallow passage, is undergoing especially rapid evaporation, and there is a continuous flow of water into it from the main sea, gradually increasing its concentration of dissolved salts. The ratio of salts in the Caspian is not identical with that in the ocean owing to the influx of large rivers, and a closer comparison to ocean salts can be made with those of Great Salt Lake (analysis 2) in Utah, an evaporating lake whose tributary rivers drain for the most part areas of rocks formed by deposition in the ocean but which was never itself a part of an ocean. Its concentration, owing to the arid climate, is about four times that of the ocean.

Comparison of analyses 1 and 2 shows in the latter a total disappearance of CO_3 and an almost total disappearance of Ca from solution, and readily accounts for the oölitic calcium carbonate sand found along the lake's margin. Calcium carbonate is insoluble in a brine of this composition and concentration. Limestones and closely related dolomites ($CaCO_3$.-$MgCO_3$) of this mode of origin are rather widely distributed. Analyses 3 and 4 show successively further concentrations in the Dead Sea at the surface and at a depth of 300 meters. Here most of the sulphate radicle and much of the sodium have been precipitated and are represented by many beds of gypsum ($CaSO_4$.-$2H_2O$) and rock salt (NaCl) in the vicinity. The analysis closely resembles those of bitterns remaining after the artificial extraction of salt from sea water. A little potassium, to judge from the two analyses, has been deposited in some form; but potash salts as a whole are deposited among the very last products of evaporation.

The Stassfurt Deposit

The complete process is illustrated by the occurrence at Stassfurt in Germany (Fig. 1) from which nearly all the present potash supply of the world is mined. The details of the chemistry of deposition are very complicated and not yet fully understood, but the principal stages accord with those of the modern cases above cited. The first deposit, below the section shown in figure 1, was a bituminous limestone; above this came gypsum ($CaSO_4.2H_2O$) and the closely related anhydrite ($CaSO_4$), and next in order rock salt and anhydrite. In artificial evaporation of brines of this type, rock salt begins to appear when the solution has been concentrated to about one tenth its original volume. Above the rock salt came the zones of polyhalite ($2CaSO_4$-$MgSO_4.2H_2O$), kieserite ($MgSO_4H_2O$), carnallite ($KMgCl_36H_2O$) and kainite ($MgSO_4KCl._3H_2O$). The two latter minerals (with other K-Mg minerals of doubtful origin) mark the extreme of evaporation.

Following their deposition, a change in climatic conditions renewed the supply of water, which brought in fine clay with it in suspension and formed the layer of salt clay. Dilution continued until only anhydrite could deposit, when evaporation was resumed giving a second bed of rock salt;* but at this stage another change of conditions again renewed the supply of water which covered the salt series with a considerable thickness of sands and clays (now consolidated to sandstone and shale).

Gypsum and Salt in the United States

Geologic evidences of frequent oscillations in climatic conditions are very abundant and are to be found in this country in rocks of various ages from among the oldest (pre-Cambrian) down to those now in process of formation. The chances, therefore, for the total

*According to some authorities this salt bed was formed by a leaching of underlying beds.

evaporation of an inland sea, as was the case at Stassfurt are very small. Limestone (of this mode of origin) and gypsum formations are widely distributed, and in many places their intercalation with shale and sandy beds is characteristic. Even rock salt deposits, though of less frequent occurrence than gypsum, are not very uncommon, and are mined in Michigan, Ohio, New York, Pennsylvania, Kansas, Louisiana, Texas and a few other states; but in none of these deposits have deposits of potash salts been found. A boring at Goderich, Ontario,* 1517 feet deep, passed through six beds each of alternating limestone-dolomite-anhydrite and rock salt. It is possible that potash salts may have been deposited above some of the salt beds, only to be redissolved when the brine became rediluted. The Stassfurt deposit may owe its preservation to its protection by the impervious shale which was deposited upon it at the beginning of the next redilution stage. It records a most exceptional instance, not only where evaporation was allowed to continue to completion, but also where the highly soluble potash salts were protected from re-solution.

Possible Potash Deposits in the United States

But while the formation of such deposits is to be regarded in general as improbable, a most promising place to prospect for them is in the arid Great Basin region of the western United States (Fig. 2). The complete geologic history of the region is long and complicated, but only the closing stages are of importance here. In rather recent (Tertiary) time the Great Basin was the scene of great volcanic activity which was accompanied, or closely followed, by an elevation of the whole region; but, while elevation as a whole was taking place, the earth's crust became ruptured along many lines of north-south trend and broke into a number of immense blocks, which became tilted and slid past one another, producing the present striking Basin mountain ranges. This rupturing and movement has extended through a long interval and in a few places is evidently still continuing.

The total effect of the movement has been to produce among the range several more or less disconnected valleys, none of which have a low outlet. These valleys fed by streams from neighboring mountains, gave rise to several lakes shown in Figure 2. The two largest of these, Lake Bonneville (of which Great Salt Lake is a remnant) and Lake Lahonton which covered large areas in Utah and Nevada, have been studied by G. K. Gilbert and the late I. C. Russell of the United States Geological Survey. The lakes varied in volume from time to time, and at one period of humid climate Lake Bonneville rose until it stood 1,000 feet above the present surface of Salt Lake and found an outlet northward into the Snake River (Fig. 2); but since that time periods of arid climate have prevailed and the lakes have shrunk by stages, each important stage being marked by wave-cut shore lines along the mountain ranges, until today only the few small scattered remnants shown in Figure 2 remain.

Study of a large scale map of these old lake floors, especially in the Lake Lahonton area, shows that the gradual disappearance of the large lakes must have left more small bodies of water than the few indicated in Figure 2. Some have completely evaporated, and must have deposited their highly soluble potash salts. That the total amount of potash in these deposits is practically unlimited, is readily realized when it is estimated that the relatively insignificant and dilute Mono Lake in California (see Fig. 2 and analysis 5 on p. 47) contains the equivalent of 10,000,000 tons of muriate of potash.† The analysis of Mono Lake water further shows that additional deposits of sodium carbonate and borax, the former now almost wholly imported from Chile, may be expected.

* Merrill, G. P. The non-metallic minerals, Rept. Nat'l Museum, 1899, p. 198.
† Mitchell, G. E. American Potash for America. *Nat'l Geog. Magazine*, April, 1911.

QUATERNARY LAKES OF THE GREAT BASIN

Quaternary Lakes Boundary of the Great Basin

100 75 50 25 0 100 200 300

Scale of Miles

Figure 2

Such deposits may be pure, or may be mixed with silt washed from the adjacent mountains. Their purity, exact location, thicknesses and horizontal extents must be learned by prospecting with the drill. Such is the prospecting now being conducted by the United States Geological Survey, as well as by private interests, with good prospects of success.

Addenda to Foregoing

Shortly after the above article was submitted, two bulletins of the United States Geological Survey were received, giving an account of the past season's progress in the search for potash. Bull. No. 530-A, by Hoyt S. Gale ("The Search for Potash in the United States") tells of operations in the West. A study of the "Red Beds" (a series of red sandstones and shales) in southern Wyoming was first made, since many such formations are accompanied by considerable saline material; but, as analyses showed that there was less potash in spring and well waters from these rocks than in the

average of 33 representative American river and lake waters, it was decided not to pursue these investigations further at present.

The geologic conditions pointing to the possible existence of buried deposits in the Great Basin are next given, largely in a summary of parts of I. C. Russel's monograph on Lake Lahonton. There are two most striking points in this account. The first is the evidence that Lake Lahonton (and also Lake Bonneville) had two periods of high water separated by an intervening period of desiccation even greater than that which exists today. The second explains the burial and absorption of salts by clays deposited in the dry lake basins during rainy seasons, the pure salt grading upward into alternating thin layers of salt and clay and finally giving way entirely to clay. After a study of the geologic conditions the Carson Sink in Nevada was selected for a preliminary test by drilling, and by December 1 a depth of about 320 feet had been reached. A tabulated drill record up to December 1 is given showing that only sand and clay beds have been penetrated. No conclusive results have yet been reached. Similar operations by a private company are to be started in Railroad Valley, 200 miles southeast of Carson Sink in Utah.

Bulletin number 350-A, by W. C. Phalen, describes the search for potash salts in the bitterns from the salt deposits that are now being worked in the eastern United States. Mr. Phalen has visited the different salt-producing districts and taken a large number of samples for analysis. The work of analyzing the samples is now only begun, and but few analyses are given in Mr. Phalen's report. Those of brines from New York and Ohio are not promising, but one from Fairport Harbor, Ohio, of a natural bittern, containing 7.4 grams per liter of potassium chloride, is especially worthy of attention.

ISOLATING THE TYPHOID BACILLUS

While it has been recognized for a number of years that typhoid fever is a water-borne disease, bacteriologists have, with a few notable exceptions, been unable to isolate the germ of the disease—*bacillus typhosus*—from waters that have certainly carried the organism. This failure to find the typhoid microbe has been due to (1) the interval elapsing between the time that the water is infected and when suspicions are aroused as to its dangerous character, and (2) the great difficulty that exists in examining a sufficiently large quantity of water, and of picking out the typhoid bacillus from the numerous other bacteria present. These difficulties have seemed so great to most bacteriologists that they have usually refrained from making a search for the typhoid bacillus itself, and have relied merely on finding the organisms characteristic of sewage pollution and then assuming that in all probability the typhoid germ is, or at least was, present in the offending water.

While great headway has been made in the isolation of typhoid bacilli from the dejecta of sufferers from that disease, there has been no parallel progress in the isolation from water. In the past the isolation of the organisms in question has sometimes been accomplished by filtering a considerable quantity of the suspected water and then growing the bacteria collected on some special culture medium which would result in the colonies of typhoid bacilli being differentiated from the other organisms present. This has been no easy task, and the results have not been satisfactory. Attempts have likewise been made to add to the water such coagulating chemicals as lime and alum, permitting the precipitate to settle out and then examining the enmeshed bacteria. Still other methods have been devised, but none have given good results.

Doctors W. James Wilson and Charles Dickson have, however, recently developed a method of isolating typhoid

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bacilli which promises to be of great value. These investigations concentrate the bacteria by evaporating a considerable quantity of water and then making a bacteriological examination of the small amount left, using for this purpose some of the special differentiating media referred to above. Some of their results seem to indicate that this method may come into general use.

It is, of course, necessary that relatively low temperatures be used in evaporating the water, otherwise all bacteria would be killed with the exception of a few spore-bearing bacteria having little or no significance. The temperature used in the experiments of Wilson and Dickson was in no instance above 37° C., and evaporation was hastened by attaching a strong suction to the evaporating chamber. In this way four liters of water can be evaporated almost to dryness in twenty-four hours. To test the apparatus the investigators took 4 liters of water, containing 800,000 normal water bacteria, and added to it 39 typhoid bacilli and 4,100 colon bacilli, the latter being a form common in sewage and one that interferes with isolation of typhoid. This was then evaporated, and typhoid bacilli were successfully recovered from the small residue.

Having obtained satisfactory results with the apparatus, the investigators next proceeded to study the question in more practical ways. An artificial well, made of glazed earthenware pipe, was sunk in the ground, and was left open to the weather conditions of the outside air. Sixty liters of tap water were placed in the well and small quantities of the feces and urine from persons who were known to be secreting typhoid bacilli were added. Samples of the water were then taken every few days, and evaporated and examined as described. The observers were able to isolate typhoid bacilli up to the twenty-fourth day.

This fact has special significance as certain eminent English bacteriologists have maintained that typhoid bacilli were unable to survive in water for more than a week, and that less than a month's storage of a raw river water was apparently absolute protection against typhoid fever. That such statements should be accepted with reserve is evident from the findings of Wilson and Dickson, and it is also evident that the solution of the important question of the viability of typhoid bacilli in water is still an open one and in need of further study and investigation.

S. M. G.

HINTS FROM "THE WORLD OF DREAMS"

DREAMS THE SYMBOLS OF BODILY CONDITIONS—ILL HEALTH CONDUCIVE TO CEREBRAL CONDITIONS SIMILAR TO THOSE OF THE DREAMING BRAIN

BY PERCY G. STILES

Havelock Ellis, a profound student of the nervous system and a writer of exceptional charm, has given us under the title quoted above, a book both recreative and informing. It is scientific in method but none the less artistic. One comes to admire most warmly the insight of the author and his mastery of expression. To the man who has paid some attention to the imagery and emotion of his own dreams, but who has felt himself to be a hopelessly blundering amateur at this pursuit, the luminous suggestions of this skilled interpreter come home with compelling power. He sees signs of order and sequence where he had found only confusion and incoherence. He learns something of his own personality at which he may laugh or wince according to his mood.

One cannot, however, pass final judgment upon himself with a few imperfectly recalled dreams as a basis. If one makes the attempt, as sensitive and introspective souls have done, one may be put to shame by the impression of frivolous interests and unworthy aims which seem to be indicated. The specialist reminds us for our consolation that it is the best of us which sleeps most soundly and that neither dreams nor delirium ought to be viewed as fairly diagnostic of the total self. There is, indeed, an element of contrast between the dominant impulses of waking and of dreaming life, a contrast due, perhaps, on the physiological side to the fatigue of the brain mechanisms most used and the assertion of those to which free play is rarely given. This tendency is calculated to make the dreamer distinctly untrue to himself. It is in less direct and more subtle ways that the content of dreams may be self-revealing.

A marked characteristic of dreaming is the symbolizing or dramatizing of bodily conditions. An organic disturbance which the waking mind would readily refer to its actual seat is presented in the dreaming consciousness as a spectacle external to the observer. Thus, we are told, a palpitating heart is not recognized as such by the sleeper. The impression derived from its labor is set before him as the picture of a horse struggling up a steep hill, a man striving to scale a wall, or some such objective example of strenuous toil. A full bladder which demands relief appears in curious metaphor as a fountain playing or an overflowing cistern. Still more remote from their literal character are the representations of a disordered stomach. These may be translated into scenes of battle, torture and mutilation. Distressful sensations are suggested but they seem to exist for the persons whom the dreamer is watching rather than for him.

Havelock Ellis shows us that such a mental process is not so foreign to our daytime experience as might at first be supposed. We have a preference, sometimes amounting to a frailty, for ascribing our feelings to external causes. The singer who ends his song in a glow of exaltation does not recognize how largely his quickened circulation is the source of his optimism. It seems rather to him that the world is just then particularly benevolent and attractive. The illusion is not undesirable. The man at the banquet, with a small percentage of alcohol at large in his veins, thinks that his friends are more than commonly witty and admirable. He invests them with a glow which has its origin in his own modified cerebration. The mode

of formation of dreams is certainly a telling caricature of such psychology.

It is interesting to note that the sick brain conducts itself in many cases like the dreaming brain. This is obviously true when the patient has hallucinations; it can be discovered also when the disorder is much less in degree. For it is the habit of one who is uncomfortable to be aggrieved at his neighbors. This again is dream reasoning, the transfer to others of something for which one's own state is responsible. The invalid who can wholly avoid it must be a rare character. When discomfort increases, the attendant is regarded as negligent and unsympathetic. When the symptoms abate, he is conceived to have become more thoughtful and kind. How quaintly this approaches the absurdly erroneous thinking of the dreamer! It seems to him that he has nothing to do with the exhibitions of malevolence which are annoying him. Yet all the time they are detachments of himself!

This is not written to diminish sympathy for those who suffer. The odds may be insuperable. But for the man who lays claim to abounding health the moral is clear. He is to look to it that his mind operates as that of a waking man and has not the obliquity of the dreamer's. It is his task rightly to estimate the degree of intrusion of the factors which warp judgment—joy and grief, physical well-being and physical depression. In so far as he succeeds—in so far as he views his fellows and his circumstances at a valuation which does not change with his own condition he is a sane man. In the light of Doctor Ellis's exposition he merits the distinction of being called *awake*.

STORAGE BATTERY ELECTRIFICATION

It is reported in the technical press that the Illinois Central Railroad is to buy three storage battery motor cars, using the Edison storage battery, to experiment with in connection with their suburban service in the city of Chicago. It is stated that these batteries can be charged in about forty minutes with enough electricity for a two-hundred-mile run. If this be true, the field opened for electrification along these lines is extremely attractive, as it will, if successful, enable a railroad company to gradually electrify its system by the substitution of locomotives or cars propelled by the storage battery, for steam units as fast as the latter are worn out.

By this means, the financing of the electrification may be extended over a period of years without requiring any enormous expenditure at one time. The fact is, that the only difficulty at the present time in the way of the electrification of any railroad is the large item of expense involved in the necessity of making the change, provided either trolley or third rail is used, suddenly instead of gradually. Such a sudden change, involving as it does, the practical throwing away of steam equipment before it has outlived its usefulness, involves a financial burden that is most difficult to meet.

The storage battery, if successful, will also solve the question of yard electrification in the very best possible manner. Requiring no overhead or third rail construction, the storage battery locomotive can be grafted onto the present steam systems without any disturbance of equilibrium. With the many new developments constantly coming forward, the conservative attitude on the part of the railroad managers with regard to electrification is to be commended. The public in its desire for electrification should not forget that the expense of experimenting as well as the expense of the final change to electricity, must be borne by the traveling public and those who ship their goods over the railroads.

L. E. M.

LECTURE BEFORE THE SOCIETY

Dr. Charles G. Abbot, director of the Astrophysical Observatory, Smithsonian Institution, Washington, D. C., will deliver an illustrated lecture on "The Sun's Radiation," in Huntington Hall, Tuesday evening, February 20. Public is invited.

SPICES AS FOOD PRESERVATIVES

Food preservation has occupied the attention of the public to a very considerable extent during the past few years and the marked activity of both State and Federal governments tending to do away with the common practice of adding certain chemical substances to food products in order to prevent spoiling, or to hide the use of inferior goods or unsanitary methods of manufacture has met with very general approval. An interesting contribution to this general question of food preservation has recently been made by Conrad Hoffman and Alice C. Evans of the Agricultural Bacteriological Laboratories of the University of Wisconsin.

These observers point out that "sodium benzoate has been of particular interest because some experts maintain that it is not harmful to the human system when used in quantities that will prevent the growth of microörganisms in food, whereas others ascribe injurious properties to it, and strongly condemn its use. However, much of it has been used, especially where an inferior grade of material is utilized, and as yet there is no law preventing its use." With this in mind they have made an investigation of the preserving properties of certain spices which are commonly used, and which have not been criticised as objectionable.

Ginger, black pepper and cayenne pepper failed to prevent the growth of microorganisms, and consequently to retard the spoiling of foods. Nutmeg and allspice were found to delay the growth of such organisms, but only for a very few days, so that these spices, also cannot be considered of practical value as antiseptics. Cinnamon, cloves and mustard, on the other hand, showed very marked powers of restraint over the growth of microbes and are to be considered as valuable preservatives. Cinnamon and mustard are considered particularly valuable, "for they are palatable even when used in proportions that prevent all growth." Cloves when added to foods in a proportion which would prevent growth gave too much of a burning taste.

The active antiseptic constituents of mustard, cinnamon and cloves are the aromatic or essential oils which they contain. Clove buds contain about 15 per cent. of essential oils, the greatest part of which is eugenol, or oil of cloves. Cinnamon gives about 0.5-1 per cent. of essential oils, and about 70 per cent. of this is cinnamic aldehyde which gives cinnamon its characteristic odor. Eugenol is also found in the essential oils of cinnamon. Experiments were made to test out the preserving efficiency of cinnamic aldehyde, and it was discovered that even the smallest portion used—a little over 1-100 of a gram to 100 grams of apple sauce—delayed growth sixty days, and that double this amount prevented growth entirely. These proportions were not sufficient to affect the palatability of the food.

Using organisms that had previously been isolated from spoiled tomato ketchup, the relative efficiency of cinnamic aldehyde, eugenol and benzoic acid was next investigated. It was found that cinnamic aldehyde possessed more marked antiseptic power than either of the other two compounds. Of the three, benzoic acid was by far the least effective.

The investigators sum up their experiments as follows—"In case of cinnamic aldehyde a concentration of two parts per 10,000 was sufficient to inhibit the growth of most organisms, only two out of the nine employed showing growth at this concentration. With eugenol five parts per 10,000 proved insufficient to prevent the growth of all the organisms tried, four out of nine having grown. Benzoic acid, on the other hand, revealed a much weaker antiseptic action than either of the above, eight forms out of nine growing in a concentration equivalent to ten parts per 10,000, and five out of nine in a concentration of twenty parts per 10,000, while three others showed doubtful evidence of growth." In conclusion the authors recommend the use of cinnamon and cloves as against such spices as pepper and ginger, and suggest that the more liberal use

of the two former spices may perhaps remove the necessity of adding sodium benzoate for preserving ketchup,—a practice to which there has been so much objection.

The full paper is to be found in the *Journal of Industrial and Engineering Chemistry*, November, 1911, pp. 835–838.

S. M. G.

"HOLES IN THE AIR"

A POSSIBLE explanation of some of the recent disasters in aviation may be arrived at in the following manner:—

In the first place it must be clearly understood that the planes of an aëroplane must move through the air in order to be sustained by it. It makes no difference whether the aëroplane is stationary so far as the earth is concerned or not so long as the air moves under it. A very familiar example of this is the ordinary kite. When in the air it is stationary so far as the earth is concerned as it is held by the string. The wind blowing underneath it sustains it. The "pull" on the kite-string is a measure of the force needed to pull the kite through the wind. The aëroplane is merely a kite in principle except that, to enable it to move readily from place to place, an engine turning a propeller which revolves in the air is substituted for the kite-string.

Suppose an aëroplane weighing 1,000 pounds, with a 50 horse-power engine to be running at the rate of 30 miles an hour and the air to be moving in a direction exactly opposite to that of the aëroplane at a speed of 30 miles an hour (or 44 feet a second) with respect to the earth. The aëroplane is then stationary so far as the earth is concerned and the engine is exerting power enough to sustain the machine and hold it against the prevailing wind. It is possible to turn an aëroplane through a half-circle and head it in the opposite direction in three seconds. Suppose the aëroplane is now headed in the opposite direction in three seconds. In order to be sustained in the air at the same level with no increase in power consumption for sustention the aëroplane must continue to move with a speed of 30 miles an hour with reference to the air or, in its changed direction, running with the wind, at a speed of 60 miles an hour with reference to the earth.

That is to say, a body in the air but initially at rest with reference to the earth must acquire within three seconds a velocity of 60 miles an hour. Everyone is familiar with the inertia effect by which any object resists having its speed changed. This is a perfectly definite amount under given conditions and can be accurately computed by the methods of mechanics. To change the speed of this aëroplane under the given conditions will require the exertion of 73.4 horse-power. A part of this comes from the air itself blowing on the machine but the greater part comes from the engine—which was only of 50 horse-power to start with. Under these conditions it is evident that it is impossible for the aëroplane to be accelerated quickly enough by the engine without using all the power required for sustention. When the power required for sustention is used for some other purpose the aëroplane falls. Once it has started to fall it will probably be nearly impossible to right the machine and acquire sufficient velocity to sustain it before it strikes the ground. This is an adequate explanation of the "Swiss cheese" sky found on gusty days. The aëroplane must have a sufficient velocity with reference to the air to sustain itself. In a lull between gusts it must increase its velocity very quickly in order to have sufficient speed to be sustained. The inertia of the machine prevents a sufficiently quick change of velocity and the machine drops through what undoubtedly seems to an aviator like a "hole in the air."

L. E. M.

THE Trans-Uruguayan Railway which is now in process of construction will be about 370 miles long. It starts from Colonia opposite Buenos Ayres, Argentina, and runs almost due north of San Luis on the northern frontier where it will be linked with the Brazilian system. The entire line will take some years to complete.

EFFICIENCY IN PUBLIC HEALTH WORK

PAPER READ AT A MEETING OF THE AMERICAN MUNICIPAL LEAGUE BY SELSKAR M. GUNN—ECONOMY AND EFFICIENCY GO HAND IN HAND UNDER PROPER CONDITIONS

Any estimate of what constitutes economy and efficiency in health administration work cannot be regarded as satisfactory until the true functions of a health department have been properly defined. Such an understanding has not yet been attained, although the progress of sanitation in the last few years,—resulting largely from the wonderful discoveries of bacteriology and the remarkable achievements of epidemiology,—is gradually bringing a truer conception of the nature of those conditions which have not imaginary, but real health significance. A study of the annual reports of various health departments of this country reveals great variation—both in the objects pursued and in the detailed methods of attack.

Health authorities are being relieved gradually of the burdens of garbage and refuse collection and disposal, plumbing inspection, poor relief, and general hospital maintenance—matters of slight if any public health significance. Consequently, they are becoming more and more able to devote their whole time and energy to questions of real sanitary import—to the solving of problems which will actually result in the decrease of preventable sickness and in conserving human life and happiness. Again, it is generally conceded that at the present time health departments are usually inadequately financed. New funds are not granted for the furtherance of the work of the department, or if so, to only a limited extent. It is doubtful, however, if the funds now actually at the disposal of the health authorities are being spent with *real* economy.

One of the chief causes of inefficiency and lack of true economy is to be found in the lack of proper knowledge as to the comparative importance of the various branches of work which may be pursued. A health commissioner is confronted with the question of what he ought to do to improve the sanitary status of his community. He has limited funds, and consequently cannot do all that he might wish. "Shall I make a special effort to curb tuberculosis, or devote my resources to improving the milk supply?" "Should meat and food inspection be developed before factory inspection?" Questions similar to those are constantly confronting every modern sanitarian in charge of a city health department, and the decisions that have to be made are not always easy or evident. However, it is only by developing such a sense of proportion that efficient administration can be obtained.

It is natural that health department organization should be far from perfect in most places. Their growth has often been unplanned, and the lack of knowledge in the past has largely prevented an orderly and scientific development. What might have been considered good organization twenty years ago would not be able to stand criticism in the light of modern discovery. We find at the present time that certain lines of activity receive far more attention than their actual importance would warrant. Excessive emphasis on meat and food inspection, and an accompanying neglect of milk supply supervision is a good example of this. The particular hobby of a health commissioner may lead to an unbalanced state of affairs, and is to be particularly guarded against. Again, the special prominence of some problem may lead the health officer to undertake work out of all proportion to the actual needs, and to the detriment of some other part of the service.

An interesting example of the great variation in the activity of health authorities with regard to work of the same character has recently come to my attention and will bear repetition here. The number of samples of milk and cream examined chemically in twenty-seven large cities of the United States varied from 4 to 344 per 10,000 of population, and the number of samples of milk tested bacteriologically in twenty-four of these cities varied from 0.6 to 288 per 10,000 population. (These figures are for the years 1909 and 1910.) While it is improbable that a standard number of analyses based on the population could be set, it is not unreasonable to maintain that these figures show that the health departments of some cities are devoting too much attention to this work and are allowing other lines of work to be neglected, while other cities are neglecting this work although they may be overemphasizing in other directions. It certainly seems that those cities which are making so many chemical analyses are really going to excess in this particular, and that no added benefit in the form of a purer milk is being obtained for the city on account of this *unusual* activity. In one of the large cities which analyzes a great number of samples, the dairy farm inspection work of the department is practically *nil*, the inspectors having to spend so large a part of their time in the laboratory testing samples. The law of diminishing returns is a real factor in inspection work.

If we could really get at the relative importance of all the activities of a health department, we should be in a position to apportion the necessary funds in a scientific manner, giving due weight to each line of work. The death rate of a city cannot be used as a measure of the efficiency of the health authorities. The fallacy of this method of determining the health status of a community has been conclusively demonstrated. Most careful studies of vital statistics are necessary, and the good derived from some lines of endeavor cannot be demonstrated by any statistical methods yet devised. The remarkable statements of some health officers concerning the health of their city would be amusing if they were not so serious as indicating ignorance on the part of this most important city official. Apparent economy may be attained by an untrained man, but in most cases true economy, combined with efficiency, cannot be had unless the health administration is in the hands of an individual thoroughly trained in the sanitary arts. It cannot be expected that anyone who has not received special training, or who has had merely the few hours of hygiene allotted to the subject in a medical school curriculum, is a proper person to be put in charge of the public health activities of a community. The first essential for any city which is honestly seeking to maintain a health department of real value is to secure the services of a trained sanitarian. There is no alternative in this matter. For small communities which are unable to pay for the services of such an individual, it has been suggested that neighboring communities may combine, and so secure the services of an efficient man as the executive for all.

A comparison of the requirements for employment in public health service in this country with those of England, Germany and other European countries, reveals to us a quite unsatisfactory condition. In the foreign countries special evidence of fitness is essential. The state of New Jersey, in the past few years, has required all persons who desire to enter public health service anywhere in the state to pass an examination, and to obtain a license. By this means many who are unfitted by lack of knowledge and training have been excluded from the service. Other states might well copy this progressive step. Too long have we played with the public health. It is a disgrace that severe epidemics are necessary to bring home the lessons of inefficient service. Nor does the necessity for trained officials end with the appointment of a health officer or commissioner. His subordinates should likewise be subjected to suitable examination. The growth of the Civil Service is a step in the right direction.

Among the common methods used by

sóme health officers to combat insanitary evils is what I shall term, for want of a better word, the "outburst" method. I refer to transitory outbursts of activity directed at some particular business or condition which is supposed to have a bearing on the public health. Sometimes the bakers or ice cream dealers are subjected to a sudden and severe examination as to the sanitary conditions of their places of business, or maybe the fly nuisance is selected for a special campaign of theoretical extermination. While this method of occasional activity is sometimes the only available one for an undermanned department, and occasional inspection and sampling are better than none at all, yet I venture to remark that eminently better results could be obtained by regular and reasonable inspection. It should always be borne in mind that the strength of inspection lies in frequent *reinspection*. Furthermore, the persons concerned prefer a regular inspection and certification. What health officers need is the co-operation of the public, and particularly of those engaged in industries or affairs which have a bearing on the public health. The educational value of frequent and friendly inspection needs no special argument to any who have been working on the problem of dairy farm inspection.

Real efficiency naturally incorporates in it economy. As has been pointed out by the Bureau of Municipal Research of New York City the question of "whether administration has been economical or wasteful can be determined only by contrasting cost with service results." The investigators of this Bureau have emphasized the proper recording of service results, and especially at times when the budget is being considered. While it is true that it is difficult, and at times impossible, for a health department to demonstrate by means of figures the actual beneficial results of various of its activities on account of the complexity and diversity of conditions which may produce a particular disease, yet in certain lines it is eminently practical. We can see it in the city of Richmond in the reduction of typhoid fever, and in the improvement of the milk supply. The results of efficient service are demonstrated in the annual reports of the chief health officer, Dr. E. C. Levy, whose brilliant work has attracted the attention of all progressive sanitarians in this country. Methods similar to those used in this city should be employed elsewhere. They are essential for *scientific budget* making and should be a great aid in asking the city fathers for more money. Even at the best it takes time to get the needed appropriation, but this time may be considerably shortened by using modern methods to demonstrate the needs.

Accounting methods of health departments as evidenced by the financial statements contained in their annual reports are in need of some standardization if proper use is to be made of them. It is almost impossible for cities to compare their expenses with other similar communities. The Massachusetts Association of Boards of Health some months ago appointed a committee to draw up an outline of a form for use by the local city boards in their annual reports. The form of the financial statement is being carefully considered by this committee as an important part of its work.

In a number of cities bureaus of municipal research are in operation, and are doing constructive work in reorganizing the activities and accounting methods of the health departments. This should have a very beneficial effect if carried on with the proper co-operative spirit, and should assist materially in the preparation of a sensible and clear budget that will interest the citizens and win their support.

In conclusion, it seems to me that in order that we may have health departments both economical and efficient, we must free them from politics with its accompanying uncertainties and strife, and place them in the hands of trained sanitarians who shall understand the relative importance of the different lines of endeavor and who will then be able to disburse an adequate appropriation in such manner that the community will receive the maximum protection at the lowest possible cost.

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MONSTERS AND THEIR PRODUCTION

NEW LIGHT THROWN ON THE CAUSES OF ABNORMAL CREATIONS—EXPERIMENTAL RESEARCH HINTS AT METHODS OF CONTROL AND PREVENTION

Smithsonian Institution JUL 22 1915 Astrophysical Observatory

BY CHARLES R. STOCKARD

THE laity wonders at the so-called monstrous appearance of the deformed child or the ill-formed young of lower animals. It seems strange at first sight that any individual could develop in an unusual way, and possess a part differing greatly from the corresponding structures in other members of the species.

The student of development, however, in realizing the intricate and delicately balanced organic mechanism concerned in the formation of the embryo, marvels that the cords of nature are so well attuned. The wonder is that all the processes and complexities of development so often follow one after another in proper order and give rise to that splendidly made organic being, a bird or a man! How countless the chances for deviation, how sensitively the plastic organism responds to the surrounding forces, and yet how frequently the normal goal of development is attained.

What is that normal goal; what is the mean around which the variations play; and what latitude may variations attain? Among the millions of human beings in the world each of us recognizes our individual acquaintances by their facial appearances, no two appear exactly the same. Yet all are men. Facing these countless minor diversities why should one wonder at the occurrence of greater deviations?

Any individual presenting a structure unusual to us is said to be deformed. Each extremity in man generally terminates with five digits; if there be more or less than five the hand is deformed. Children born with two heads are double-headed monsters, but if for hundreds of years the majority of children had been of this type, then we would be single-headed monsters (provided, of course, we existed in our present condition).

The monster is the unusual, it may be entirely unfitted for a worldly existence or it may be as capable of living as its ordinary brothers.

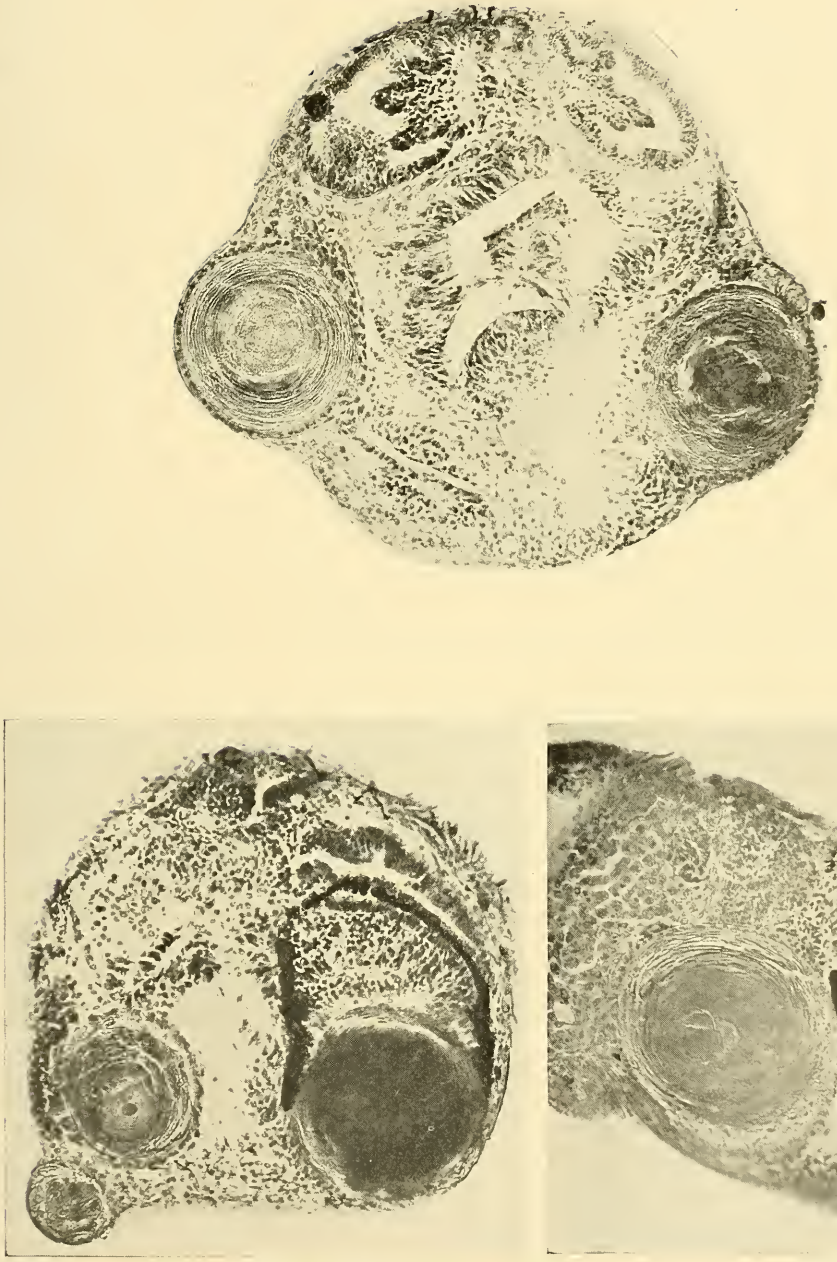
What causes these abnormalities; and is it in any way possible to control or regulate their production?

The first clause of this query has excited curiosity as far back as human records exist, and it must be answered before the second part is ready to be attacked. The ancients believed that the gods sent deformed beings as tokens of good or evil. Statues of many of the gods were of monstrous forms and visages.

Unhatched fish embryos which were artificially caused to develop various types of eye abnormalities. The first four illustrate different degrees of the Cyclopean defect. The next two are monophthalmica asymmetrica, the two below are different ages of a three-eyed monster.

The constellations and heavenly bodies were also thought to influence the production of monsters. The appearance of monsters were often interpreted as tokens to the tribe of some fortune or misfortune that would befall them. These mythical ideas gave way to others equally as fanciful and only in recent times have people come to understand or realize the true significance of deformed beings.

The study of embryology and investigations into the normal development of animals enabled the biologists of the last century to appreciate the fact that monstrous forms are merely the result of unusual or abnormal development. Nevertheless, it is surprising to find that even today one of the most absurd of the ancient traditions remains in the widely prevalent idea that "maternal impressions" are the cause of monsters. Many instances are cited of pregnant mothers having been frightened by vicious animals and having later given birth to children resembling in appearance the particular animal, as a result of the men-



Microphotographs showing cross sections of crystalline lenses formed independently of the development of other eye parts when the retina is almost or entirely absent.

tal impression stamped by the mother upon her offspring. These cases are mere coincidents and the resemblance to the animal is highly imaginative.

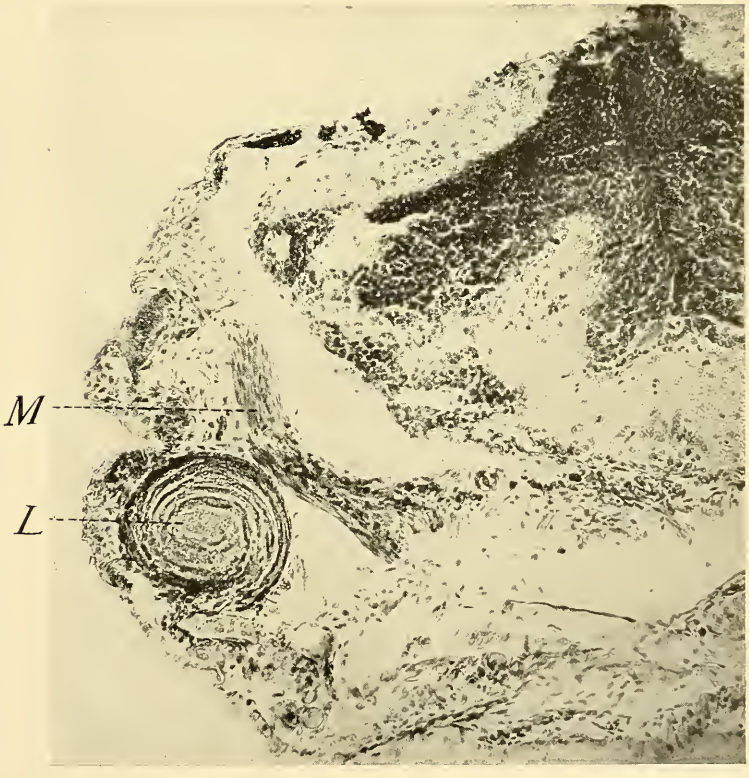
The study of embryology experimental and systematic has shown that all types of monsters are due to one of two causes. Either the individual has sprung from abnormal or diseased germ cells, or the embryo has experienced an unusual and unfavorable environment in which to develop. If the ovum, the maternal germ cell, or the spermatozoon, the paternal germ cell, or both of these cells happen for any reason to have an unusual composition they then give rise to an offspring of unusual form. Such deformities are germinal in their origin and may be handed on to other generations. Accessory fingers and toes, cleft palate, and other defects are of this nature and continue to reappear in a family. In these cases it is the same deformity that continues to occur and by proper selection and mating a peculiar race possessing the given abnormality could be produced. This then becomes a problem of eugenics, but the guarding of the germ cells in order that they may not be affected by unfavorable or diseased environment is an important problem of hygiene, that must be considered and comes before eugenics.

As above stated, the second cause of monstrosities is the development of the embryo in an unusual or unfavorable environment. The influence of such an environment causes the organs and parts of the individual to form in a strange or monstrous fashion. Monsters resulting from such effects would not necessarily produce offspring of their special type should they chance to reach maturity and reproduce. The abnormal conditions of the monster would only be transmitted provided the environment had affected its developing germ cells as well as other parts; and further that the effects on the germ cells had been such as to cause their hereditary qualities to vary in the given direction followed by the body of the deformed individual. An embryo arising from a normal egg and spermatozoon will develop into a perfect individual provided the developmental environment is favorable. The egg of a marine fish develops normally in pure sea water, the egg of a fresh water species develops in fresh water. Cases are extremely rare of marine eggs developing in fresh water and *vice versa.*

If the normal development of the embryo depends upon a given environment either chemical or physical, the experimenter is then enabled to modify the development by modifying the environment. He thus causes an egg to develop into a new or strange being, and by properly adjusting the chemical or physical nature of the developmental environment he is enabled with a certain degree of accuracy to produce a typical structural defect.

Experiments of this kind completely defeat the old ideas and superstitions regarding the causes of abnormal individuals. Further, they hold out a most alluring hope in that by an analysis and control of embryonic development the physician may some day be enabled to prevent the occurrence of deformities in our race. This is not entirely a fanciful speculation. If it is possible to modify development in certain definite ways the next step must logically be the arrangement of a method which will insure a more nearly normal development from formerly diseased or weakened mothers.

I may now briefly cite in a very simple fashion some of the experiments which have gone to show that by modifying the germ cells of either the male or female parent the offspring is also modified. When the male frog is treated with radium or the X-ray its germ cells are affected by the treatment and all the eggs fertilized by such a male develop into abnormal tadpoles. When the female is similarly treated, before she has spawned, all of her eggs develop abnormally even though they are fertilized by an untreated male. When both parents are treated the embryos resulting from their mating are still more abnormal. Thus Bardeen and O. Hertwig have shown with frogs that a defective germ cell causes a defective offspring, and this defect may be derived from either the mother or father.



Microphotographs of cross sections through the eye region of fish embryos. The upper photograph shows an eye on one side of the brain but none on the other. The lower figure shows a perfect crystalline lens on an eyeless side.

The writer has in progress a series of experiments with guinea pigs which now show that if either the father or mother be artificially put into a condition of chronic alcoholism the offspring develop abnormally. The animals are allowed to inhale the fumes of alcohol for six days per week to almost the point of intoxication. When normal females are bred with alcoholic males the fœtus is either aborted before the end of its development, or is born dead, or dies shortly after birth showing various nervous symptoms and dying in convulsions. All of these conditions are due to the effect of the alcohol on the germ cells of the father. When an alcoholic female is mated with a normal male, the same result follows. This is also true when two alcoholic individuals are paired. Thus the abnormal chemical environment induced by the alcohol in the blood of the parent affects its germ cells as well as other tissues of its body and causes a father to beget an abnormal offspring and a mother to produce a defective fœtus.

Abundant statistics show that in the human race the excessive use of alcohol produces effects of very similar nature. I may mention only one or two records out of the great number available to those interested in this subject. Charles Sullivan showed in 1899 that of 600 children born of 120 alcoholic families 335, or 55.8 per cent., died under two years of age. Many of the survivors were epileptic, tuberculous, and generally weak. The percentage of children born dead increased with successive births. While of the first born 33.7 per cent. were dead at birth, the second born 50 per cent., the third born 52.6 per cent., the fourth and fifth born 65.7 per cent., the later births actually averaged 72 per cent. stillborn. Indicating that as the mothers became more and more alcoholic the offspring was less well developed.

Kende studied 46 alcoholic families. Of 21 such families in which both parents were alcoholic 10 were childless, while of 24 children born to the other 11 families 16 died soon after birth and only 3 of the 24 were "entirely" normal. In 18 families, in which only the father drank, 21 children were born; of these only 3 were healthy while the number of abortions and the cases of sterility were very high.

The French observer Nicloux has demonstrated that alcohol passes from the blood of the mother into the tissues of the fœtus. Identical amounts of alcohol were demonstrated in the maternal and fœtal tissues.

Women occasionally give birth to several deformed children by one husband and to several healthy children by a second consort.

These cases of the influence of the abnormal father on the offspring prove that the modified germ cell also modifies the resulting individual. This, of course, we would expect as the germ cells carry within themselves all the hereditary qualities of the race, and these carriers are at base chemical in nature, it follows, therefore, that when they are chemically changed or disturbed their tendencies are modified.

The second cause of abnormalities may now be considered: The influence of the environment on the developing embryo. The embryo is delicately adapted to its normal environment, and, changes in this environment cause modification of various degrees depending directly upon the amount of change from the normal surroundings. The human embryo may be modified by changes in the chemical composition of the mother's blood, due to diseases or intoxications of various kinds or by faulty nutrition from any cause. Interesting examples may be cited among women employed in lead works, where they often become poisoned by the fumes. Women who had formerly produced normally healthy children have during employment in such places produced abnormal offspring which were frequently aborted before term. Constantin Paul long ago found in studying 88 cases of pregnancies among women lead workers that 71 resulted in abortion, premature labor, or still birth, while only 17 children were born alive and of these 5 died within the first year. Several of these women later produced healthy children after leaving this work. Lead not only affects the

Drawings of unhatched fish embryos which show different stages of artificially induced suppression of the eye development. The upper left-hand specimen has no eyes, nevertheless two perfect crystalline lenses (L) have developed.

developing fœtus, but also acts directly upon the germ cells as is shown in the records of men working in lead while their wives were not exposed to the poison. Many of the offspring from such fathers are aborted and the children born are epileptic, feeble-minded or generally defective.

I have been able to experimentally produce a definite type of deformity of certain complex organs or parts by certain treatments of the eggs during various stages of their development. By properly regulating the treatment fish's eggs may be made to develop into embryos, 98 per cent. of which will show eye abnormalities. When one subjects the eggs to a given strength of alcohol for a few hours and then returns these eggs to ordinary clean water a large number of the embryos resulting will exhibit abnormalities of the brain and central nervous system. The eyes and ears are also abnormal. Many embryos show the so-called Cyclopean defect, having one eye in the middle of the face instead

of the usual two lateral eyes, recalling in appearance the ancient Cyclops of Greek mythology. The drawings of fish embryos illustrate the curious eye conditions. With stronger doses the embryos may be caused to develop entirely without eyes, or in other cases one eye forms in its usual position on the side of the head while the other eye is small, defective, or entirely wanting. Monsters of the last type I have called monophthalmica asymmetrica in contra-distinction to the median-eyed or symmetrical Cyclopean forms. These grotesque individuals may be produced by treating eggs with other substances than alcohol, such as ether, chloretone, magnesium, etc., and when the doses are properly adjusted a surprisingly regular result will follow. In one experiment 98 in 100 eggs were caused to form these abnormal individuals. The Cyclopean fish hatch and swim about actively, and may be kept in the aquaria where they feed and grow. The sensitive part, or retina, of the eye is developed in the embryo as a diverticulum from the brain while the crystalline lens folds in from the outer wall or ectodermal layer and associates itself with the retina or optic-cup in such a fashion as to focus images upon its concave surface. Numerous experimenters have held that when the retinal part or sensitive portion of the eye is removed from the early embryo the lens fails to develop, being in such cases useless. This is not true, however, as the Cyclopean and eyeless embryos show that although no eye forms, or ever begins to form, yet a perfectly differentiated crystalline lens may exist. The accompanying illustrations will show this fact. The lens is transparent and is in all respects similar to one that exists within the eye. The embryo, therefore, possesses an innate tendency to form the crystalline lens independently of the associated parts of the eye.

The ears are likewise deformed or absent in fishes developing from eggs treated with alcohol. In some cases only a small portion of one of the semicircular canals of the ear exists, and in these cases the bony structures which form about the ear to give the bony semi-circular canals fail to develop, and only surround the tiny ear portions which are present. In a few of these embryos the two ear vesicles are excessively large and may unite so that the animal has an ear extending entirely across the back of its head.

All of these experiments, which I have so briefly and I fear so inadequately presented to you, go to demonstrate the extreme plasticity of living stuffs and give some idea of the many dangers which beset the developing individual. Thus it is that one does not wonder at the abnormalities and ill-formed individuals in nature but rather at the vast number of successfully formed beings.

Having shown that development may be disturbed in various directions and that the embryo responds so readily to treatments of different kinds, the question naturally presents itself, may the development of the individual be regulated or guided so as to give a more nearly normal result? Statistics show that in the human race about 23 per cent. of the conceptions of "perfectly normal" mothers result in abortion or abnormal fœtuses. This is truly a high mortality record. One in every four individuals is ordinarily lost before the time of birth. When we include diseased and abnormal mothers the figures are greatly increased.

Many people suffer and ultimately die as the result of congenital defects. Very few indeed are born in a *perfectly* developed condition. This pre-natal destruction must be looked upon as a great disease which sweeps away one quarter of the descendants of healthy parents. No single post-natal disease presents such a frightful death record. Yet little, if anything, is being done to regulate the development of man.

Preventive medicine has made strides in the control of infectious diseases, but it has done scarcely anything towards correcting this great disease of construction in the bodily make-up of the race. To produce a physically vigorous man or an efficient mechanical engine we must build with well-formed parts.

THE BROWNIAN MOVEMENT

THE REMARKABLE PHENOMENON WHICH HAS HELPED TO PROVE THE ATOMIC THEORY AND THROWS NEW LIGHT ON "PERPETUAL MOTION OF THE SECOND KIND"

BY D. F. COMSTOCK

In 1827, the naturalist Brown discovered the fact that minute solid particles in a liquid undergo a ceaseless vibratory motion which is easily visible under a microscope. As a matter of fact the phenomenon is so clearly visible that biologists in examining bacteria have to learn to distinguish between life-motions and the so-called "Brownian movement" which bacteria have in common with all minute solid particles.

For a long time it was supposed that this ceaseless motion was due to some outside cause. It was thought, in fact, that the motion was similar to that of the dust particles which we often see moving back and forth in a beam of sunlight. As time went on however it became clear that this was by no means the case. It has since been definitely shown that the following statements are true:

(1) The agitation is more violent the smaller the particle;

(2) The nature of the particle does not appear to be of any importance;

(3) The motion persists without the slightest abatement when the liquid is left for an indefinite time at constant temperature;

(4) The motion seems to be completely independent of all the outside effects which might be expected to affect it if it were not something very fundamental indeed.

Although it is quite impossible to attribute the motion to any of the disturbing causes which were at one time supposed to produce it, it is nevertheless exactly what mathematical analysis shows is to be expected on the atomic theory of matter. The molecules are, of course, almost infinitesimal in size compared with the particles we are now considering, but the molecules have at ordinary temperatures considerable energy for their size, and their motion must be considered as totally chaotic, so that in bombarding very small particles as they do, it will very rarely happen that the forces of impact are equalized in all directions. The usual result will be that any one particle will be bombarded more vigorously on one side than on the other. A particle, like an insurance company, in order to be permanent amid the losses and gains of individuals, *must be large enough to feel the steadying influence of large averages* and the small particles which we observe are *not* large enough for this. They therefore execute a random movement, first one way and then the other, far slower to be sure than we suppose the individual molecules to move but still amply sufficient to be seen under a microscope.

This supposition, that the Brownian movement is due to molecular heat motion, which is an integral part of the atomic theory immediately suggests a number of ways of verifying this theory itself. A remarkable series of experiments have recently been carried out by Professor Perrin of the University of Paris and have led to the conclusion that the Brownian movement is completely explained as a deduction from molecular mechanics. Professor Perrin succeeded in preparing a solution which contained particles of practically one size only and he made a complete quantitative study of the actions under a number of different conditions, of these particles; their average motion, for example, and their distribution under the pull of gravity. In all cases, not only was the general nature of the phenomena the same as that which can be predicted from general molecular

theory, but the magnitude also was in accordance with it.

There can therefore now be no reasonable doubt that we see in the Brownian movement the direct heat motions produced by the molecules themselves. The motion is not confined to the solid particles which we can readily see with a microscope, but takes place in reality throughout the whole mass of any fluid. The particles serve merely to indicate the motion of the otherwise invisible fluid. We reach therefore the result, surprising from the viewpoint of ordinary life, that *a liquid mass when left to itself does not tend to come to rest.* It only appears to come to rest as regards its larger portions, but its smaller portions remain in visible chaotic motion indefinitely.

To quote Professor Perrin, "Thus comes into evidence, in what is termed a *fluid in equilibrium*, a property eternal and profound. This equilibrium only exists as an average and for large masses; it is a statistical equilibrium. In reality the whole fluid is agitated indefinitely and spontaneously by motions the more violent and rapid the smaller the portion taken into account; the statical notion of equilibrium is completely illusory."

The satisfactory explanation thus rendered of the Brownian movement brings up some interesting considerations respecting what has sometimes been called "perpetual motion of the second kind." This latter should not be confused with "perpetual motion of the first kind," which is popularly known simply as "perpetual motion," and corresponds to the actual *creation of energy.* A perpetual motion machine in the ordinary sense, if it could exist, would be one which would give out energy without taking energy in. The impossibility of the existence of such a machine is perhaps the surest physical law we know. Perpetual motion of the second kind is quite different, but so far it too has been found impossible. The so-called "second law of thermodynamics," states that although heat is a form of energy it cannot be extracted from a hot body unless there be somewhere a difference of temperature or its equivalent. Thus there is heat enough in the ocean to supply more than enough energy for any imaginable human activity, but this heat is all practically at the same intensity (*i. e.*, temperature) and therefore, it is "unavailable energy."

Now those who have thought carefully about these fundamental physical laws have long realized that this second law of thermodynamics, the law which states the unavailability of heat when there is no difference of temperature, is probably only true on a relatively large scale. In other words, it is not true that a body placed in surroundings of constant temperature cannot be set in motion at the expense of this heat. It is only true that a body *large enough to be of practical importance* to us now cannot be so set in motion. A steamship cannot be propelled by means of energy abstracted from the relatively constant-temperature ocean round it, but a far smaller object, namely one of the particles which we observe under the microscope, *is* so propelled for short distances. There is no difference whatever between the one impossibility and the other actuality except that of magnitude.

This does not mean, of course, that the so-called "second law" has been found at last to be "untrue." It means that it is an essentially statistical law and should not be applied to very small portions of matter in the same way as it is to large ones.

By all odds the most important result of Professor Perrin's work on the Brownian movement is the verification it gives of molecular theory. These results alone, many think, would furnish a solid, convincing proof of the general truth of the theory and when they come, as they do, as a supplement to other proofs already obtained, the final probability of its truth can be considered now as little short of certainty.

Professor Perrin's papers on this subject are already classical and it would repay anyone interested to read the little book called, "Brownian Movement and Molecular Reality," translated by F. Soddy, M.A., F.R.S. (London: Taylor & Francis, Red Lion Court, Fleet Street, 1910.)

Slate Group: Mycerinus and His Queen, Fourth Dynasty—Courtesy of *Museum of Fine Arts Bulletin*, Boston

THE DAWN OF CIVILIZATION IN EGYPT

TRACING THE CULTURE OF THE EGYPTIANS NEARLY TO THE STONE AGE—MUMMIES NOT OF ANCIENT ORIGIN—THE SECRET OF THE SPHINX REVEALED

In a course of eight lectures before the Lowell Institute Professor George A. Reisner outlined the dawn of civilization in Egypt and brought down the improvement in the mechanic arts through its most important period, that of the building of the pyramids. The three salient facts that dominated the lectures were that the ancient Egyptians were living in the Stone Age, that the mummification that is popularly taken to be the important accompaniment of burial was but a phase of it in the later years and that the Sphinx is the statue portrait of Chephren and furnished with its lion's body stands to ward the spirits from the tomb of that monarch, the second pyramid. About these facts was woven a most remarkable story of rise and fall of the nation, wastefulness, conservation, change in character of the monarchs and marvelous improvements in the methods of handling stone and other materials.

The first of the lectures was a clear exposition of the kind of evidence and the methods of securing it. The later results have been accomplished by the joint expeditions of the Boston Museum of Fine Arts, and Harvard University and which were along very different lines from the methods of years ago. It was undertaken on the plan of commercial enterprise, the ground inspected, the methods of attack outlined, and when once the work was begun it was followed in every detail by a group of trained specialists. The synchronous operations included excavation, card cataloguing, photography and the mapping of the cemetery. For it should be understood that what is known of the life and habits of the old Egyptians has been preserved through the accompaniments of burial. The man in the spirit world needed the things which he had been accustomed to use in life, and these were buried with him.

With reference to the efficiency of the work Doctor Reisner noted that for the excavation of a cemetery of two hundred and fifty graves, only eight days were necessary and on the ninth day after the photographs were taken of the untouched ground, the work had been finished and the laborers sent elsewhere for other excavations.

In showing the extent of the excavations, Doctor Reisner stated that in view of the flooding of the country by the raising of the Asouan dam, the Government of Egypt had asked that everything of archæological or historical value be taken up. There were one hundred and fifty miles of sand-blown desert, apparently a hopeless task, but it was possible to march an army of pickaxe wielders in lines across the country. A single stroke of the pick was enough to determine whether it was worth while to do more, and in this way the whole area was prospected at the rate of several miles a day. There were, of course, fundamental principles underlying the method, one of them being that remains would be found only in soil that had been overturned, so that if the single stroke showed the natural geological structure, it was useless to spend more time.

The chronology established by Doctor Reisner and his assistants is the following:—Pre-dynastic, B. C. 4500 to 3300; first and second dynasties, B. C. 3300 to 3000; Old Empire, B. C. 3000 to 2400; and Middle Empire, B. C. 2400 to 1600. The New Empire then ensued till about B. C. 1200, then the Egyptian Renaissance, and from B. C. 663 down was the Persian Period. This chronology does not reach such enormous antiquity as have some other computations of the past.

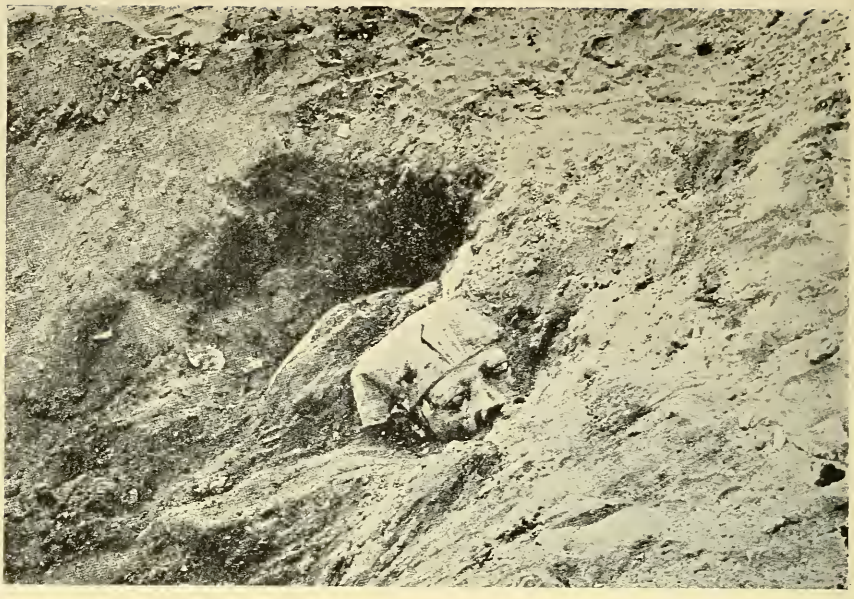
Valley Temple of Mycerinus in Process of Excavation. Pyramid of Khufu (Cheops) Beyond—Courtesy of *Museum of Fine Arts Bulletin*, Boston

An interesting portion of the second lecture was the outlining of the basis on which this chronology rests. There is a fixed date, that of Alexander in B. C. 332, and back of that about thirty years an Egyptian priest, Manetho, made a list of the kings of Egypt. Some of his figures are wrong, much of his material is as yet unidentified, but much remains good in the light of other evidence. There is a papyrus in Turin written apparently in the New Empire on the back of which some one has placed a list of the kings including the mythical ones. The list seems to be accurate, but there are important breaks in it of four or five hundred years. Then there is the Palermo stone, resting in the museum of that city, but carried to Sicily, no one knows how, perhaps as ballast. This is the annual record of the height of the Nile, which in an interesting manner identifies the year by the action of some king. Then there are the inscriptions in the tombs.

In his second lecture Doctor Reisner took up the chronology and race mixtures.

"It is not the question at the moment which is the more ancient," said the lecturer, "but it is true that the Egyptian relics have been much better preserved. In Egypt there was a people whose whole life is now known to man and in its study it is possible to trace the culture back to a time that was pretty close to the Stone Age."

The speaker said that the dates presented by him are less distant by two or three thousand years than those given by some writers in published works, but he believes that his figures are founded on valid authority.



First View of Head of Alabaster Statue of Mycerinus—Courtesy of *Museum of Fine Arts Bulletin*, Boston

As to the people the sculpture indicates clearly distinct immigrant racial types, Negro, Berber, Arab, Philistine and Asiatic. Skulls found have been restored to the semblance of the living man, and from the whole investigation it would appear that with the native Egyptian stock two races were mingled in ancient days; in the north, the Semitic stock was mixed with Berber and Libyan immigrants, while in the south it was the original Semitic mixed with Negro. It was the northern mixture that developed the country and built the splendid monuments and cities. In the south the people have done nothing and are now about where they were in the pre-dynastic days.

The illustrations that Doctor Reisner presented at his third lecture showed the actual material from which this ancient history has been reclaimed and roughly the time may be divided into the Stone Age when the metals were practically unknown, the middle pre-dynastic, when traces of copper are to be found and then the later period when copper was used for the heavier articles such as effective weapons. Certain kinds of pottery or stone ornaments belong infallibly to certain periods.

The Egyptian Stone Age man was weaving baskets and cloth, dyeing his cloth, tanning, making pottery by hand and decorating with crude, yet unmistakable representations of the animals and objects about him. He could cultivate at least one sort of grain, barley, for the dissection of well-preserved stomachs has presented the grain undigested. It is also true that the whole country was culturally a unit, a fact abundantly proven by the universal distribution of articles, like stone objects, whose original locality can be proved by the parent ledges. And again some of the most interesting objects of the decorative art were ships of weird and wavy pattern, which their vases have preserved. It is thus unquestioned that the Nile was in the earliest days used for trade and articles made in few places had universal distribution.

As one of the important matters in which the people are generally mistaken in their notion, Doctor Reisner called attention to the peculiar posture in which the ancient men along the Nile buried their dead. The body was doubled up with the knees near the chin and the hands before the face. The head was usually

First View of the Slate Group of Mycerinus and His Queen—Courtesy of *Museum of Fine Arts Bulletin,* Boston

towards the south. The mummy, which everyone associates with Egyptian burial, is, comparatively speaking, a modern innovation, although the earlier kings were indeed mummified. Much was told about the plundering of graves, which has been done in all ages for the valuables buried with the dead.

The progress of the country was admirably shown by the mineral contents of the graves which serves to give an additional measure of their antiquity. In the earliest tombs galena and an oxide of iron, used for a face paint, were found.

Then in the next period appear some manufactures of gold or copper and in the last of the pre-dynastic periods heavy items, weapons first, because more necessary, characterize the findings. The invention of the needle was another of the interesting stories, illustrated by pictures of the specimens themselves. The awl was used for five or six hundred years in ancient Egypt till the first crude needles were made of copper spindles with the top bent to one side making an eye, and centuries afterwards it occurred to someone to drill an eye through the spindle itself.

Doctor Reisner stoutly defends his neolithic Egyptians against the claims that they were cannibals, showing first that but few instances in the thousands of graves examined, perhaps one grave in five thousand, afforded the evidences that had been brought forward in support of the assertion that they ate their fellowmen. Some joints apparently gnawed were shown by the speaker to bear the marks of predatory beetles which attacked the bone for its enclosure of marrow.

"We have thus seen," said the lecturer, "that the Egyptians grew from savages to learn gradually the arts of metal working; they became prosperous and with prosperity came the struggle for wealth. The effect of this was to divide them into two great factions, one in lower Egypt and the other in upper, and for one hundred years before the first dynasty there was a constant struggle for control. These factions were united by King Menes."

Something of the political history of the Egyptians showed how when there

Upper Part of Slate Group: Mycerinus and His Queen, Fourth Dynasty—Courtesy of *Museum of Fine Arts Bulletin,* Boston

was prosperity, there came union between the different tribes and the whole of Egypt came under the rule of a single sovereign. The holding of the wealth in the hands of a single family resulted in the expenditure of the surplus in great public works which took the form of tombs of kings, etc., enormously costly even with slave labor, and in Egypt there were alternate periods of financial depression and wealth. This is shown in the tombs, for the implements attending the interment in the midst of a panic in Egypt were inferior in quality and number. The graves thus tell after many centuries much of the financial story of the country.

There were many interesting inventions, for example, the mechanical stone pot-borer. First there is in the tombs an inferior quality of clay vases, these improve and later when it was possible the first art declined in favor of machine-made stone vases. The older clay vessels were reserved for religious purposes and occur in the graves with the others. Later better pottery vases replaced the stone ones, these being the ups and downs of the arts, and Doctor Reisner expressed the opinion that no art is ever lost until there is a better one ready to take its place.

Much of the earlier story had to do with the construction of houses. Information about this is conveyed by the tombs which are of the same type. It was a mud-brick architecture with wooden rafters to support the roof. Later the lintel and the arch were used, the latter being one made by corbelling out the bricks till they met, limited to what could be held up by the hands till the key was placed, while the obliquely-laid barrel arch was known to these people. This could be made without the need of a form to hold it while under construction.

Of the ancient Egyptian architecture

Doctor Reisner presents the same idea that other speakers have brought forward in discussing the Greek architecture, that the later work of the country merely followed in some other material the forms of the earlier, cruder material. The original building of the Egyptians was with a mud brick. The people never lived in caves, as has been asserted by some others who seek to trace the architecture to such an origin.

And somewhere in here there came the invention of letters.

There was outlined how culture spread among the people. While it was true that the kings reserved the best workmen for their own edifices, still there were slack times, when the stone masons and sculptors went home while others sought other employ, so gradually it was possible for minor princes and officers to secure excellent art.

The answer to the riddle of the Sphinx was the most striking climax of Doctor Reisner's lectures, the unfolding of the remarkable work of the Boston-Harvard expeditions in determining what the Sphinx really is. It is a portrait of Chephren, the builder of the second pyramid, mounted in the usual way on the body of a lion to ward away the evil spirits from the tomb. This discovery came about in a perfectly logical manner. Doctor Reisner set deliberately at work to unearth for the second pyramid what experience had shown should be somewhere, a valley temple, lower than the pyramid and connected with it by means of passages. This was found by excavation and in the end, from its position the real secret of the Sphinx was unravelled. When the fact was discovered it was fairly easy to verify it by comparisons with other portraits.

Already at the third pyramid the same kind of investigations had been carried forward and its relation to Mycerinus established. It proved to have at its base what was sought with the advanced knowledge of Egyptian customs, the temple of the king who erected the pyramid. From this it is customary to have a gallery extending down hill to a lower temple. These items were found, but not until a sixth dynasty temple, covering the original one of the fourth dynasty, was opened and removed. The outlines of the two temples were established and in excavating the splendid statues of Mycerinus and his queen were discovered, the alabaster statue of the king and a series of slate triads, three figures to a panel.

The story turned largely about Mycerinus, the builder of the third of the pyramids in the great group, and his wife, whose statues recently excavated from his temple, form a showing in the Boston Museum of Fine Arts which is declared to be incomparable and priceless. The wonderful alabaster head in the same department of the Museum is that of his son.

These monuments present a faithful picture of Egyptian art, a picture that is not to be duplicated in the case of any other nation of antiquity. The arts reached the finest stage, reliefs, statues, magnificent buildings, and after the sixth dynasty it may be said that the Egyptians learned nothing more excepting the making of glass. The time has been termed the Pyramid Age, in which there were erected these enormous and beautiful temples and tombs.

Household processes like weaving, domestic arts like harping and singing, the wine press, hunting, shipping on the Nile, fishing and netting birds, the agricultural processes, plowing, reaping, threshing, and trade operations of weighing and storing—all are shown. From the monuments the life of the people is made known. The tombs give the relics on which can be based the knowledge of durable productions, vases, pottery and other manufactures, while the tombs themselves afford a good working knowledge of Egyptian architecture.

The most striking exposition of the whole series of lectures from the mechanical point of view was the development of the art of masonry almost within a single generation at the time of the building of the pyramids. Before then the work had been of mud-brick and of stone in imitation of this, but now there came into existence the extraordinary ability to

cut, handle and lay stone that has hardly had its parallel in all mechanics.

Important side issues of history, the development of painting and of sculpture formed an interesting framework within which this technical knowledge was set.

THE BOSTON SUBWAY

The Cambridge Subway soon to be opened, brings up the question of the general plan of subways which is being developed in the city of Boston. The situation in the city of Boston is peculiar because if the business district be considered at the center of the wheel, the territory which must be reached from this center is nearly three fourths of a complete circle. It is manifestly out of the question to build subways or elevated railways to each one of the outlying suburbs on account of the great cost. The general plan being followed, then, is to build two combination subway and elevated systems which cross each other at right angles in the central portion of the city. The one running north and south will extend when completed from Malden on the north to Forest Hills on the south. At the various stations along this line, surface cars come in and transfer their passengers to the elevated. By this means the surface car traffic is to a large extent kept in the outlying districts where the congestion of streets is a minimum, and passengers are transferred from the surface cars to the elevated system which then brings them in to their destination.

The other line being developed extends from Cambridge on the west under Beacon Hill at present as far as a new station built underneath the present Park Street Station. Ultimately this is to be extended down Winter and Summer Streets, past the South Station and thence in a southerly direction to Andrew Square in South Boston. When this whole scheme is completed, surface cars will be collected principally at Harvard Square from Cambridge and the suburbs in that direction and at Andrew Square from Dorchester and South Boston.

The terminal station at Park Street is so built that when the tunnel is completed, it will become a way station instead of a terminal without any structural changes. At Harvard Square and at Park Street, the stairways are such that the transfer from surface cars to the subway and *vice versa* is made without the use of any transfer checks, and the platforms are so arranged that in any given passageway people can move in only one direction. There are also separate loading and unloading platforms for the subway trains which tend, of course, toward freedom of movement, as people leaving and entering trains do not meet. At Harvard Square there are also loading and unloading platforms for surface cars for the same reason. The whole arrangement is part of a very carefully worked out plan for accelerating the movement of traffic. For instance, the present running time of surface cars from Harvard Square to Park Street is twenty-three minutes. The running time of the subway trains will be between seven and eight minutes. When this subway is completed to South Boston, it will be seen that ready means will be afforded to transfer to and from the old Tremont Street Subway as well as to and from the Washington Street Tunnel. It will also give better access to the South Station than has heretofore been practicable.

L. E. M.

LARGEST OIL PROPELLED SHIP

The *Toiler*, an oil engine ship, 248 feet long and drawing 14 feet loaded, is said to be the largest vessel afloat driven by oil. This ship has but recently entered the Great Lakes for use by the Anglo-Saxon Petroleum Company. She has twin screws driven by two 4-cylinder 180 horse power reversible Diesel oil engines. The machinery weighs 60 tons less than equivalent steam equipment. The oil is carried in a double bottom where water ballast is usually carried. The use of oil instead of coal effects a saving of 120 tons. The German battleship *Goeben* is now being built which it is said will have the central shaft driven by a 12,000 horse power Diesel engine.

VENTILATION OF SLEEPING CARS

CONDITIONS OF COMFORT IN PULLMANS AND PUBLIC BUILDINGS IMPROVING, BUT THE PROBLEM OF REGULATING HUMIDITY NOT YET SOLVED

BY JOHN F. NORTON

In spite of the luxuries of the modern sleeping car, most of us have spent many uncomfortable hours in traveling. This discomfort is more marked during the winter when the doors and windows of the car are kept tightly closed than during the summer when we can sit in a draught of air blowing through a window screen. Further, the discomfort is increased whenever the train stops, and if we get off to get a breath of air, upon returning we are forcibly impressed with the "close" odor in the car, which only disappears after the train has been going for some minutes. Again, we probably spend the most uncomfortable hours in a berth closed by green curtains which seem to shut out what little air we think there may be in the aisle. We go to bed over a hot steam pipe, and if we are fortunate enough to finally get to sleep, we are only too liable to wake up feeling a need for more blankets. If we are obliged to take a 3 a. m. train, and consequently must spend several hours in a car standing in a station, our discomfort is still greater. Some of us always arrive at the end of our journey, if not with a headache, at least with a very dull feeling. We blame the ventilation of the sleeping car for all the discomfort and ill effects of traveling.

Let us first consider the conditions which cause us to feel comfortable or uncomfortable. The air we breathe is a mixture of gases. Nearly four fifths is an inactive gas, nitrogen; about one fifth is oxygen, and the rest is carbon dioxide, moisture and some rare gases. The important constituents for us to consider are oxygen, carbon dioxide and moisture. Whenever we burn coal, wood or gas the carbon in the fuel unites with the oxygen in the air to form carbon dioxide. When the amount of oxygen has decreased beyond a definite value the fuel refuses to burn. For instance a candle goes out when the per cent. of oxygen in the air is 16 per cent. or less. Now respiration is a process of a similar nature; we breathe in oxygen and exhale carbon dioxide. Outdoor air contains about 20.81 per cent. of oxygen and .04 per cent. of carbon dioxide, while in expired air the oxygen has been decreased to about 16 per cent. and the carbon dioxide increased to 4.38 per cent.* Thus we are continually using up the supply of oxygen and replacing it by carbon dioxide. Expired air immediately mixes with the air in a room and this in turn is being replaced by fresh outdoor air, so the actual amount of carbon dioxide in a room only very slowly increases, even with all the doors and windows closed. It is interesting to note that we can breathe in air which contains less oxygen than is required for a candle to burn.

At one time it was thought that the carbon dioxide with which we contaminate the air was responsible for the effects produced by bad air, but even in a "stuffy" room the amount rarely exceeds .5 per cent., while many times this amount is required to produce any injury to the human system. We do, however, still use the amount of carbon dioxide as an index of the purity of the air, not because it is itself harmful, but because it shows us whether we are getting fresh air or are using the same air over and over again. Furthermore, since we know the amount of carbon dioxide in pure air, and the amount exhaled by a normal person in an hour, about 0.6 cubic feet for an adult man, we can calculate the amount of fresh air which is being supplied, and thus

*Foster, quoted by Soper. "Air and Ventilation in Subways." Wiley & Sons, 1908.

obtain an idea of the efficiency of the ventilation.

Another idea as to the cause of discomfort in a close room is as follows. A variety of substances is given off from the body both in the breath and in the perspiration. The amount of these substances is really very small, but as some of them have very marked odors they are readily detected, particularly when allowed to accumulate in a room. It was believed for some time that these had poisonous properties and were the cause of nausea and headaches experienced in a crowded room. From this arose the term "crowd poisoning." Some years ago it was shown by experiments on animals * that these substances were not poisonous and so we have had to give up the idea of "crowd poisoning."

If discomfort is not due to any substances which are given off from the body either in expired air or in perspiration, how, then, can we account for it? At the present time the cause is generally considered to be due to the physical conditions of the atmosphere, and the factors which we must study are temperature, humidity and motion.† These factors affect the rate of removal of heat from our bodies, and it is this heat which makes us feel comfortable or uncomfortable, and causes headaches and nausea. Now, heat is removed from the body in three ways: first, by evaporation of moisture, for we know that when a liquid changes to a vapor, heat is absorbed; second, by conduction, just as heat is transmitted from the hot to the cold part of a piece of iron; and third, by radiation through the ether. If the air is dry evaporation is rapid and consequently heat is removed faster than when the air is moist. Furthermore, heat radiation takes place more rapidly in dry than in moist air. On the other hand, since moist air is a better conductor of heat than dry air, the greater the amount of moisture the more rapidly is heat removed from the body in this way.

In order to make this discussion concrete let us take a few examples and apply these physical principles. Suppose that the temperature is 95° Fahrenheit and the humidity, that is, the ratio of the amount of moisture in the air at a given temperature to the maximum amount which the air will hold at that temperature, is 90 per cent. Under these conditions of high temperature and high humidity most of us are uncomfortable and we describe our sensation as "oppressive." The amount of heat leaving the body by means of evaporation of moisture is very small because the air already contains nearly as much as it can, and what moisture does evaporate immediately saturates the air surrounding the body and prevents any further evaporation. If the air is in motion this condition is somewhat remedied because the saturated air is being constantly carried away and its place is being taken by fresh unsaturated air which can take up a little moisture. The effect of this on our comfort is familiar, for we are all aware of the pleasure of even a slight breeze on a hot, muggy day.

The amount of heat removed from the body under these conditions due to the heat conductivity of the air is also small; for, although the actual conductivity is comparatively high, this is counteracted by the high temperature, because the interchange of heat between two bodies takes place more slowly when the difference in temperature is small than when it is large. In this case the difference is only about three degrees. The heat removed by radiation is also small, for, as stated above, radiation is diminished by the presence of moisture.

The result of all these effects is to prevent the escape of heat from the body, with the consequent uncomfortable feeling, which is of the same kind, although of a much less degree, as that given by a sunstroke.

Suppose instead of having a high we have a low temperature, for instance, 15°; but we also have high humidity. At this temperature air will hold only about one twentieth as much moisture as at the higher temperature. Consequently the

* Formánck. Archiv für Hygiene, 1900, 38, p. 1.
† Hill, quoted by Gulick, *Science*, 1911, 33, p. 327.

amount of moisture evaporated even at a low relative humidity will be small, and at the high humidity which we are considering, the loss of heat in this manner will be very small indeed, and moisture will remain on the surface of the body causing us to feel chilly. Loss by radiation will also play a less prominent part under these conditions. The chilly feeling will be further increased by the comparatively rapid loss of heat by conductivity due to the large difference in temperature between the air and the body, and to the high humidity. If the air is in motion, we are much more uncomfortable than when it is still, for as before, this tends to increase the loss of heat, which we wish to prevent under the given conditions.

From the above discussion it is evident that in order to feel comfortable at various temperatures we must have comparatively low humidity. However, if we decrease the humidity too much we again feel uncomfortable, and it is this condition which we find all too frequently in houses, public buildings and sleeping cars. Indoors, most of us prefer a temperature of 68° to 70° and a humidity of 60 to 70 per cent. If the air is drier than this we raise the temperature in order to be warm and very soon this higher temperature has its effect by producing a sleepy feeling. One of the most noticeable differences between outdoor and indoor air is that of motion. The air in a room, unless the ventilation is of the best, is in a more or less stagnant condition, and heat, moisture and other products of respiration are carried off very slowly, while outdoors we are continually being supplied with fresh air, even when there is little noticeable breeze.

To sum up, then, in order to feel comfortable the heat given off from our body must be carried away from us at the proper rate, and this rate is dependent on the atmospheric conditions of temperature, humidity and motion. Let us see to what extent a proper adjustment of these conditions is aimed at and obtained in the sleeping car.

The older types of car, some of which are still in use, are ventilated simply by opening the deck windows in the top of the car. It is surprising that this method is as efficient as tests have shown it to be, particularly when the car is moving at a high speed. But the ventilation is not evenly distributed, and drafts are created. The recently built cars all have some kind of forced ventilation. The type of ventilator in most general use on Pullman sleepers is known as the Garland ventilator.* This works on the principle of the aspirator or injector, which is to draw the air out of the car by maintaining a suction. The motion of the train causes air to enter a duct located on the top of the car, from which it passes out at the side. In this duct is an opening connected with the inside of the car, and as the air rushes past this opening a suction is created which draws air out of the car. It is claimed that this ventilator will draw 18,000 cubic feet of air per hour, and as each car is equipped with ten ventilators this gives a total of 180,000 cubic feet, or enough to completely change the air in the car every three or four minutes. No inlets are provided for this large volume of air, and, consequently, it must enter around the doors and windows, which even in the best built cars are not air tight. Cars ventilated in this way are heated directly by contact with steam or hot water pipes.

A system based on another principle is in use on the Pennsylvania railroad, and was developed after some years of experiment.† Here the heating and ventilating are combined. Outside air enters hoods placed at diagonal corners of the car, passes down to a duct under the floor, then up to another duct where it is heated by coming in contact with hot steam pipes, and finally enters the car in the aisle through pipes under the seats. In the car the air rises and passes out through ventilators placed above the lamps. This system is also designed to change the air in the car about every four minutes.

These three methods of ventilation

* Railway Age. 1906, 42, p. 847.
† Proceedings, Master Car Builders' Association, 1908, 42, p. 338.

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have one difficulty in common, that is, while they work reasonably well when the train is going at full speed, they are less effective at slow speeds, and give almost no ventilation when the train is standing still. In other words the amount of fresh air drawn through the car is directly dependent on the speed of the car. To remedy this, it has been suggested that fans be installed for use during stops. This would particularly be of service to those who are obliged to spend several hours in a sleeper standing in a terminal.

A short time ago a large number of tests were made on the air of Pullman cars in order to determine the efficiency of the ventilating system.* Samples of air were taken from different parts of the car, both when the train was moving and when standing at stations, and also from occupied and unoccupied berths. These samples were analyzed for carbon dioxide, which was used as an index of the purity of the air. From the analysis and the number of people in the car, the amount of outdoor air which is entering per hour can be calculated, that is the amount necessary to maintain the carbon dioxide at the value found by the analysis by dilution of exhaled air with outdoor air. The results obtained in this work led the investigator to conclude that plenty of fresh air is supplied in cars in motion, and even when standing still the contamination was not sufficient to be dangerous to health.

Still there is no doubt that a sleeping car does get "close" and "stuffy," with a resulting discomfort to the occupants. What causes this if analyses show that the air is not bad? Obviously we must look into the same factors which are responsible for our comfort or discomfort outdoors or in our houses, that is, the temperature, the humidity and the motion of the air, and the problem of sleeping car ventilation becomes the problem of regulating these conditions.

The question of motion of the air has been practically solved by the various ventilating devices, and any additional regulation can readily be made by means of electric fans. It is not considered practical † to regulate the humidity in a car, although if this could be done it would be one of the greatest factors in increasing the comforts of travel. The problem at the present time seems to be that of obtaining some efficient method of regulating the temperature of the sleeper and there is good reason to believe that this will be solved in the near future.

* Crowder. Archives of Internal Medicine. 1911. 7. p. 85.
† *loc. cit.*, p. 132.

SCIENCE FIGHTING AGAINST DISEASE

HEAD OF THE PASTEUR INSTITUTE OUTLINES THE PROGRESS OF MEDICINE AND INDICATES WHAT IS STILL TO BE ACCOMPLISHED

In a recent article written for the New York *Sun*, Professor Elie Metchnikoff, head of the Pasteur Institute, shows the progress of science against disease and points out what is still to be accomplished. This is an interesting record and we give it in full:—

Last summer I took two of my non-Russian colleagues, who were for the first time in Russia, to the Peschersky monastery in Kief. The monastery produced upon them a very deep impression. They were struck most of all by the appearance of the throng of pilgrims who were waiting in the courtyards and in the garden. The concentrated expression of their faces, which bore for the most part the imprint of profound grief, aroused a special sense of pity.

"We are partly responsible for this collected mass of misery," I said to my companions.

No doubt many of those who were there had come for the purpose of saving themselves from disease or for the purpose of praying that their nearest kin be healed of their ailments. It would be hard to imagine more effective evidence of the helplessness of our medical science. Indeed, what a great number of diseases there still remain against which medical art is powerless! With regard to such dreadful misfortunes as certain forms of insanity, numerous nervous diseases and malignant tumors science is groping in the dark. Powerless also is medical science against numerous children's diseases, against ailments of the heart, of the blood vessels and the kidneys.

It is remarkable that even in the case of numerous diseases whose causes have been definitely established there are no satisfactory remedies. The bacteria which cause all forms of tuberculosis, the pneumococci of pneumonia, the staphylococci and the streptococci which are the causes of various forms of suppurations, have been investigated in all their details and yet no positive remedy has as yet been discovered with which to combat them.

Nevertheless, hard work is being done in all institutions devoted to medicine in order to discover remedies. Aside from the hospitals and medical faculties this work is energetically carried on in special institutes whose aim it is to combat diseases. Every year their number is increased, and not only in Europe, but even in Japan, in Africa and in North and South America such medical institutes are doing successful work, as, for instance, at the Rockefeller Institute in New York and at the pathological institute at Rio de Janeiro.

Special attention is paid at these institutions to tropical diseases, the first place among which is held by the blood disease which was brought over to Europe more than 400 years ago, and which is raging everywhere. During the last year the greatest attention was directed with regard to this disease to the effect of salvarsan (606) introduced by Ehrlich.

The practical application of salvarsan called forth a large number of articles, chiefly of a polemic nature. Criticisms were directed with particular zeal against it chiefly by certain French physicians, who took a too narrow nationalistic view of the matter. Since salvarsan was discovered by a German, it could have no healing effect, especially since it became the subject of the most unbridled advertisements, they argued. All fatal cases that occurred after the application of salvarsan were immediately ascribed to its injurious action, notwithstanding the fact that salvarsan was often resorted to at the last moment, when the life of the patient was hanging on a mere thread.

But the cure of all possible forms of blood disease is a problem of such great importance that, notwithstanding the zeal of the opponents of salvarsan, Ehrlich's discovery has conquered for itself a solid place in medical practice.

It is true that the too great expectations of certain physicians and especially the public, who thought that a single injection of salvarsan was sufficient to produce a complete cure, were not realized.

Although the majority of deaths after the use of salvarsan cannot be ascribed to that remedy, there are certain cases in which it may cause death. According to Ehrlich there is no more danger to life in the use of salvarsan than there is in chloroform—even less. At any rate, salvarsan should be used very cautiously and should not be administered to patients with very weak, nervous systems and with certain derangements of the blood vessels and the heart.

A very interesting discovery which raises the hope that a vaccine virus may be discovered against the blood disease was made during the last year by the Japanese scientist, Noguchi, at the Rockefeller Institute in New York.

But salvarsan proved useful also in curing other diseases. In this respect the facts concerning the treatment of another disease of tropical origin, known as frambosia, are particularly interesting. Being very contagious, children are easily infected by it, and the disease is raging among entire communities in certain regions. It had spread and taken such deep root in Dutch Guiana that until recently there seemed no possibility of checking the disease. But since the discovery of salvarsan it has been used there extensively.

A special hospital was opened at Surinam, where patients suffering from frambosia were gathered, and to each one was administered a sufficient dose of this medicine. Two weeks later the last patient, and there had been 328, was discharged. As all the patients had been cured the hospital staff was dismissed and the hospital closed.

As I pointed out a year ago salvarsan cures not only chronic diseases, but also acute diseases, such as recurrent fever. As a rule, one injection is sufficient to produce a complete cure. This fact has been established in Russia, Spain and the Congo Free State.

Nevertheless it is necessary also in the case of recurrent fever to take preventive measures. As it is being ever more firmly established that this disease is spread by certain insects special attention is called to these insects. This same plan is effective even against a more dangerous disease than recurrent fever, namely typhus. After it had been definitely established that the latter is transmitted by the bite of an insect a campaign was started against these insects in southern Tunis, where typhus was raging. Simple measures of enforcing cleanliness and of burning material which harbored the disease-carrying insects were employed, under the direction of Doctor Hober, and proved sufficient to check the epidemic. It is surprising that in Russia, where recurrent and typhus fevers are so widespread, no efforts have as yet been made to guard against these diseases by restoring to hygienic measures.

Typhoid fever, which is of far greater importance than spotted or recurrent fever, was the subject of new investigations during the last year. Availing ourselves of the fact that this disease can be inoculated in anthropomorphous apes, Bezredko and I have tried on them the preventive vaccine against this disease. But to our surprise we found that its effect is very limited, so that this should not be taken seriously.

As a result of this other efforts were made to discover new methods of preventive vaccines. Bezredko has applied to typhoid fever the preventive method which has been discovered by him. The experiments upon a chimpanzee led to favorable results, and then the question arose as to the possibility of applying that method to human beings.

Meanwhile the former methods are used, consisting of hypodermic injections of typhoid bacteria killed by heat. In this respect we may note the inoculations made last summer by Vensan and Chantmesse upon the French troops that were

sent to Morocco and that were particularly exposed to typhoid fever. Judging by the accounts, the results were favorable, but unfortunately the information supplied in these reports is too meagre for a final judgment.

It is possible that these injections against typhoid fever will prove useful in extreme conditions, such, for instance, as in time of war or before the departure of an expedition for places that are strongly infected with the disease. But it cannot be said that they will be used extensively under ordinary circumstances. As typhoid fever infection, like that of cholera, is transmitted by drink and food, it is easy to guard against it by heating food or drink to the boiling point before using it.

The safeguarding against diseases transmitted by drink and food, such as diseases of the digestive organs, and against disease contracted through injuries to the skin of the body, such as intermittent fever and yellow fever, does not present any special difficulties. Therefore, very good results have been secured with regard to these diseases.

It is infinitely more difficult to combat infectious diseases that are transmitted by the respiratory organs and by the inhaled air. In this respect the first place is held by tuberculosis, against which no protection positive was discovered during the past twelvemonth, notwithstanding the enormous efforts that have been made in that direction. All possible serums and preventive vaccines tried on animals and in certain cases on human beings have yielded no favorable results.

Meanwhile it is necessary to conduct the struggle against tuberculosis on general hygienic measures, and although even in that respect nothing absolutely certain has been attained, still, thanks to these measures, this dreadful scourge of the human race is growing perceptibly weaker in most of the civilized countries. But this, of course, does not satisfy us, which explains our quest for new ways of solving the question of how to eradicate tuberculosis.

The tubercle bacilli of Koch have been investigated already as far as the means of modern science have permitted. With its aid the most varied preparations have been secured, by means of which efforts have been made to immunize animals against tuberculosis. In this respect something positive was even accomplished so that for some time it was thought that Behring's method might be applied with success at least in safeguarding horned cattle from this disease. But upon close investigation this also proved impracticable.

Meanwhile no artificial preventive vaccine has been discovered. And yet it is becoming ever more and more evident that the majority of people are safeguarding themselves from tuberculosis by some unknown, natural means. It has long been noticed that when the lower human races come in contact with the cultivated races the former soon develop tuberculosis in a strong degree, while the latter suffer from it only in the usual way. Does this difference depend upon the degree of racial susceptibility to tubercular infection or to some natural preventive of the cultivated races?

For the purpose of ascertaining this question, which is so important in combatting tuberculosis, we, my comrades Burne, Tarasevich and I, undertook an excursion to the Kalmuck steppes. We had to settle the question whether tuberculous infection was equally prevalent among the Kalmucks living in the steppes and those who were in nearer contact with the Russian population.

It turned out that there was a very significant difference to be noted: In the steppe, especially in its central part, there was less tuberculous infection than at its periphery. Coming in contact with the settled population the Kalmucks are infected by Koch's bacilli and they succumb to it more easily than the Russians. That was especially to be noticed with Kalmucks who came to Astrakhan for the purpose of entering the schools there. Coming there free from tuberculous infection they soon contract it, falling too often victims of the dreadful disease.

All these facts confirm the supposition as to the existence in nature of some means

of prevention which is independent of science and the human will.

All these theories are thus far only hypothetical; nevertheless they can serve as a basis for new investigations which have been undertaken as a result of our trip to the Kalmuck steppes.

The scientists are just as energetically seeking for means of combatting the other of the most dreadful scourges of the human race—malignant tumors. The amount of work undertaken for this purpose in European and American laboratories is astonishing, but until recently the results of these investigations have proved of a very slight consolation. Only toward the very end of 1911 the work of Wasserman and his co-workers appeared, raising considerable hope. The investigation of these scientists has opened a new way for treating the problem of malignant tumors which, it is to be hoped, will not be slow in yielding results for the good of suffering mankind.

In general the last twelve months have not passed without leaving some record of achievements in the struggle against our microscopically small, but none the less very powerful, enemies. Perhaps the time is not far off when scientific medicine will make superfluous such pilgrimages as that which astounded my foreign comrades who visited Kiev with me.

NEW MEMBERS OF THE SOCIETY

At the 677th meeting of the Society of Arts held February 6 the following applicants for membership were presented and elected:

Hon. James Phinney Baxter, Portland, Me.
Daniel J. Danker, 73 Dean Road, Brookline, Mass.
Henry S. Dennison, South Framingham, Mass.
William B. H. Dowse, 95 Milk St., Boston, Mass.
A. M. Guinzburg, Medway, Mass.
Harry M. Hardwick, 40 King St., Roxbury, Mass.
George W. Holden, 895 Boylston St., Boston, Mass.
Frank F. Jonsberg, 733 Old South Building, Boston, Mass.
Herbert J. Keith, 72 South Market St., Boston, Mass.
George A. Kimball, 101 Milk St., Boston, Mass.
W. F. Kimball, 7 Beals St., Brookline, Mass.
John E. Rees, Tendoy, Idaho.

PROLONGING LIFE BY THORIUM

The interesting discovery has recently been made by Dr. Werner von Bolton that the metal thorium has the property of destroying vegetable and bacterial growths, while certain forms of animal life seem to have a prolonged existence under its influence. Thorium causes fungi and even ordinary grass to die prematurely. Grass sprouts at first after treatment with thorium but dies in a short time if it is in contact with earth that has been treated with the metal. On the other hand, the lifetime of some fishes, *amphioxus lanceolatus*, is prolonged very greatly if thorium is added to their native environment, sea water and sand.

The experiments were carried out with the fish by dividing them into three lots. Two of these lots were placed in water that had been treated with thorium while the third was left in untreated water. After seven months over 90 per cent. of the fish in the thorium-treated environment were still living, while those in the untreated water died within five weeks. The walls of the vessel containing no thorium were covered with fungus, while the other two vessels were almost free from this growth. The fungus probably kills the fish and they were therefore able to live longer in the vessels where the inimical organisms had been destroyed.

It is not known whether the beneficial effects of thorium on animal life are due to the metal itself or to some other substance that is present in very small quantities. Some of the compounds of thorium have the same property but to a very much smaller degree. Other metals have been tried but none has been found to possess this singular influence.

Experiments are being carried out on other animals and it is hoped that thorium may be found to destroy some of the disease germs that shorten the life of mankind, without seriously affecting the functions of the human organism.

E. B. S.

ARCHITECTURAL ACOUSTICS

A SERIES OF INVESTIGATIONS TO DETERMINE HOW TO SECURE DESIRED ACOUSTICAL RESULTS IN PUBLIC HALLS AND ROOMS

Professor Wallace C. Sabine, of Harvard University, in a series of six lectures before the Lowell Institute, outlined the condition of "Architectural Acoustics," illustrating the papers by means of many experimental demonstrations and lantern projections. He noted in his initial lecture that the science has fallen into disrepute for it is popularly said to be impossible to determine in advance what the acoustical properties of a hall will be. This by the lectures was shown to be a fallacy and much of the time was devoted to the presentation of the results of experiments.

The investigation was due in some measure to the fact that the lecture hall of the Fogg Museum at Cambridge was found to be very bad acoustically. It was modelled after the Sanders Theatre, which is very good. The general condition which is most disturbing in audience halls is reverberation. In its highest theoretical possibility, with a room of which the walls are absolutely non-absorbent, a sound once made in the room will go on forever caroming from wall to wall. This extreme is never met of course, but in many halls the original sound continues until other sounds that are emitted, cover it and then there is confusion. An important factor, therefore, to the acoustic perfection of a hall is the absorbing quality of walls and furnishings. In the work, finding that Fogg Hall was too highly reverberative, Professor Sabine carried into it cushions from the Sanders Theatre. Every once in a while the acoustics of the Fogg room were tested and presently the investigator had a scale of reverberation expressed in metres of Sanders Theatre cushions. The scale was inconvenient, so as a substitute, open window space, was taken, which may now be used for the measure of the absorption of any room anywhere. Two other items enter into the question of rooms for speaking or for music, interference of sound and resonance. Interference is where the meeting of two sets of sound waves produces silence, which explains why in some auditoriums there are "deaf spots," while resonance is a condition in which the reflected sounds return just in time to reinforce the original sounds and make them unduly powerful.

The lectures were full of descriptions of poorly constructed places and the reasons why they fail. One house in New York was built intentionally to keep sound out, but the use of a pressed brick with a high grade cement makes a wall that is practically homogeneous where the transmission of sound waves are concerned. Then a brace or two from the brick wall to the lining of the sound-proof room made a resonator of it and noises of two stories below in the servants' quarters come forth magnified in the sleeper's chamber. In some music rooms of a college, supposed to be sufficiently guarded by the interposition of sound-proof partitions, the sound went from one to another. It was found that the pianos set the floor in vibration and the sound manifested itself in the vertical walls that rose from the floor.

One of the most interesting items shown was the method of testing the acoustic conditions in all parts of a room. A revolving arm was fixed to a vertical shaft which could be raised and lowered and a telephone was arranged on it to slide its length. It was possible by this device to place the telephone in almost any portion of the room. It was so connected that a continuous record of the intensity of a sound was made during

movements of the arm bearing the telephone. A constant sound of uniform intensity was produced and by means of the telephone it was possible to make a chart of the room in its acoustical qualities. This work is, of course, technical, but it serves to show how deeply the subject has been investigated by Professor Sabine and his assistants.

Some of the matters that were made clear were that the usual method of stringing wires across an auditorium to improve its acoustic qualities is useless because infinitesimal, to say nothing of the architectural effect. It was possible to establish a scale of absorptiveness, so that different kinds of wall decorations, cloths, curtains, rugs, sheathing, plaster walls, the portraits of one's ancestors, chairs, settees and the usual furnishings, may be rated as aids to the improvement of a hall. The coat of paint that is applied, may, under some conditions change the acoustical quality of the room by substituting a non-absorbent surface for an absorbent one. The value per individual of an audience was also tested out, the lecturer having detained a company or two at the Jefferson Physical Laboratory till midnight practically, trying the effects of additions and subtractions to the number. These and other tests were recorded by means of instruments.

The speaker noted that the idea of reconstructing a Greek theatre, which normally is fitted for out-of-door companies in warm countries, within a building, presents no good reason for the securing of the same acoustic effects. There enter into such questions materials for construction which must be taken into the reckoning.

One point of interest in the investigation was the rating of the human ear and judgment by means of scientific records. Tests were made of a number of music rooms. A committee of musicians first pronounced an opinion on the different rooms, rating them as too resonant, or too dead. Experiments with the rooms showed that no room that was pronounced dead was more resonant than the least resonant of the good rooms, so the ear judgment was confirmed by science. A similar test was made by another group of musicians of the various halls and auditoriums in the country, just previous to the building of the new Symphony Hall in Boston, and in these, science and the musical ear again agreed.

One of the interesting incidents to the story was the outlining of system with which the building of this hall was undertaken and to which it owes its excellent acoustics. The outcome of the experiments has been to place architectural acoustics on a firm basis and to make evident the fact, that today it is possible to build with a knowledge that if the proper principles are followed the acoustical result will be entirely successful.

THE GENESIS OF PETROLEUM.

The United States Geological Survey has recently contributed some interesting information relative to the connection between local magnetic disturbances and the genesis of petroleum.

Mr. George F. Becker, the investigator, states that some oils are undoubtedly organic and some are inorganic. They may have been derived from carbonaceous matter of vegetable or animal origin and they may have been derived from carbides of iron or from metals. It is possible, too, that the hydrocarbons exist as such in the mass of the earth.

In studying the connection between the behavior of the compass needle and the distribution of hydrocarbons, Mr. Becker found that on the magnetic declination map of the United States, the irregularities of the curves of equal declination of the compass were strongly marked in the principal oil regions.

The observations are to some extent supported by conditions in the Caucasus where great magnetic disturbances exist. The theory of the inorganic origin of the hydrocarbons is not proved by this study, but the map referred to above shows that petroleum is intimately associated with disturbances similar to those affected by the proximity of substances possessing sensible magnetic properties such as iron, nickel, cobalt and magnetite.

SOLVING ELECTRIFICATION PROBLEMS

In the twenty-five years of experience with heavy electric traction two problems have been most acute, the economical transmission of power to the train and the design of motors to meet the very severe requirements of the service. Through evolution the direct-current motor has reached a remarkable state of efficiency and reliability as motive power. However, it has a serious handicap, in that the power must be delivered to it at relatively low pressure, ranging from 500 to 2000 volts. The most economical method of making this delivery is to generate alternating current, transmit it at high voltage to sub-stations, transform it to a low potential by transformers and convert it to direct current at trolley voltage by rotary converters. The system is costly, complex and relatively inefficient.

The single-phase, alternating-current system is a radical departure from the above and aims at economy in power transmission. Power is transmitted at the most economical pressure and stepped down at intervals through transformers to a trolley voltage which may be as high as 12,000. The economy of copper transmission wire so obtained is great and the converting apparatus is most simple and efficient. The locomotive or car carries a special step-down transformer and is equipped with low-voltage motors. The performance of these alternating-current motors, however, is distinctly inferior to that of their direct-current competitors. They are heavier, more bulky, and more expensive. They are less efficient, more liable to spark badly and have much less reserve power. Furthermore, there is little prospect that these faults will be greatly diminished.

It is apparent that the direct-current system sacrifices economy of power transmission to excellence of motive power and that the situation with the alternating-current system is precisely the reverse. This contrast is fully confirmed in practice. The direct-current system has been most successful with dense traffic within a limited radius; the single-phase system has shown to advantage only with long hauls and infrequent stops. The most recent developments aim to mediate between the two systems and conserve the advantages of each. Simple, reliable and economical means of converting alternating current to direct is needed to supply the essential link.

One method of doing this is by means of an instrument called a rectifier.

Of all such rectifiers the mercury arc, which is in its action similar to a valve permitting current to flow in but one direction, is the most promising. As ordinarily constructed the arc is formed in a glass vacuum tube. The device is reliable and efficient but rather fragile and adapted only to small currents. A new type has been brought out in which the arcs are formed in steel tubes artificially cooled by oil or water. The tubes are made in two sections with asbestos gaskets and mercury packing to maintain thorough insulation and high vacuum. Such tubes are equally well adapted to single-phase and three-phase working. They have been built for currents as high as 300 amperes per tube. Apparently higher currents can be handled quite as easily and the device is adapted to any direct-current voltage for which motors can be wound. The sets are extremely light and compact. They may easily be carried on locomotives or cars, but a step-down transformer is required if an economical trolley voltage is employed. As a substitute for rotary converters in sub-stations the tubes will show marked advantages in first cost and operating economy. A complete outfit for fifty kilowatts (about sixty-five horsepower) gives an efficiency of 90 per cent. and large sets should attain from 93 per cent. to 95 per cent. Engineers familiar with these developments confidently predict that they will bridge the gap between the two systems of electrification.

The Paris, Lyons and Mediterranean system has been experimenting on a large scale with an entirely different device with the same end in view. It has in service a locomotive of 135 tons which receives its power from an 11,000-volt trolley and converts it to direct current by a revolving commutator driven by a synchronous motor. A transformer is used in the alternating current side to give 300-volts for the direct-current motors. The locomotive has been severely tested on a section of road having grades of 2 per cent. and hauled a train of 260 tons at an average speed of forty-five miles per hour.

It is certain that the last word in electric traction has not yet been spoken. The railroads which have been pioneering with the existing systems have achieved creditable success, but there is still much to be desired. In view of the tremendous financial burdens involved in electrification the slow growth toward a standard system justifies the conservatism of the railroads in the face of the unquestioned economy gained wherever electrification has been tried. W. E. W.

CREATING ARTIFICIAL RESPIRATION

Two machines for producing artificial respiration have recently been made public.

A German invention called the "pulmoter" consists of a tank containing oxygen at a pressure of 2800 pounds per square inch, which not only furnishes the life-sustaining gas, but also the energy required to reproduce the action of natural breathing. The oxygen flows through a reducing valve, and from there to the controlling valve. Here it has free passage to the lungs. When the pressure reaches a certain value, a bellows connected with the apparatus creates suction, causing an exhalation of the oxygen previously forced into the lungs. When a certain vacuum has been reached, the outer atmosphere acts upon the bellows in such a way as to reverse the operation. The frequency of the respirations can be adjusted to the size of the lung cavity. One of these machines is now used by the Commonwealth Edison Company of Chicago for resuscitation in cases of electric shock.

Another machine for accomplishing the same results has been devised by two physicians of Chicago, and is intended to maintain artificial respiration during operations of lung surgery. In general principle it is somewhat similar to the pulmoter, the mechanism being so devised that it produces alternate pressure and vacuum, simulating natural respiration. Recently, this machine was used to sustain the life of a patient twenty-nine hours after the time at which all signs of animation had ceased, while the surgeons were attempting to provide relief through surgical means. This apparatus introduces atmospheric air into the lungs, instead of oxygen.

DUAL WATER SUPPLY

A NOVEL scheme of dual water supply is proposed by Professor William T. Sedgwick of the Massachusetts Institute of Technology. His plan is intended to prevent the economic waste due to providing bacterially pure water for all municipal and private purposes, by providing two supplies, one for drinking and culinary purposes, and a large denatured supply for all other purposes. The special supply, being small in quantity might be found nearer a city than a large supply of high-grade water, and in any event could be readily subjected to whatever degree of purification might be required. The large supply could be taken from any convenient near-by source which afforded water of quantity and character suited to industrial purposes.

Denaturizing with a relatively large application of hypochlorite of calcium, a harmless compound used widely in minute quantities to treat potable drinking water, would give the water such a taste and odor as to shut it out for drinking and cooking purposes, and at the same time kill all possible disease germs which the water might contain.

This plan is brought forward, to meet some of the especially difficult water problems of today.

A TRIBUTE TO LORD LISTER

In a recent address before the students of Sanitary Science and Public Health at the Massachusetts Institute of Technology, Professor William T. Sedgwick paid a feeling tribute to Lord Lister, the great English surgeon who passed away this month:

"Almost the last of that splendid group of scientists of the last century," said Professor Sedgwick,—"a group that included Darwin, Pasteur, Tyndall, Hooker, Helmholtz, Spencer and Koch,—Lord Lister has passed away; he who was the discoverer of modern surgery." Pasteur and Lister and Koch formed a great micro-biological force; in 1895 Pasteur died, about two years ago, Koch, and now Lister, the last of the great trio, has gone.

Professor Sedgwick outlined the notions of the ancients on the subject of disease. There was first the theory of demons and then of the four humors. The idea of spontaneous origin of disease afterward became the accepted one and was used indeed to account for the origin of animals, the bees giving to Virgil and other poets many occasions for exploiting the idea.

When Pasteur began his work he had to meet the objections of such men as the brewers, who thought that the troubles of wine and beer were of spontaneous origin. Pasteur showed that all microbic life comes from pre-existing life, but it took a Tyndall to clinch this belief.

There was not as yet any idea of the relations of dirt to disease, but what Pasteur showed was that the whole superficial earth is quivering with life. One man had approached this idea before Pasteur, Semmelweiss, a Hungarian physician educated and established in Vienna. Deaths in the maternity hospital there were numerous, and it was noticed that in the students' clinic they rose as high as 16 per cent. of the cases. Semmelweiss found that these students came directly to the hospital from the dissecting room, and the death of one of them from a cut made Semmelwiess order hand washings and other precautions, resulting in a fall to less than 2 per cent. This was done about 1850 and without the knowledge of today that dirt means death and destruction, but it was an important movement along the same sensible lines.

Professor Sedgwick laid emphasis on the fact that before Lister's day to go to a hospital was almost to go to a slaughter house. The chances of surviving an operation were small, and it is this feeling that persists among those who depend upon tradition that makes the less intelligent classes dread the hospital today.

It was this great loss of life that Lister conquered by his methods. In 1860 Pasteur was at work on fermentations, while young Lister was a surgeon interested in the microscope and in wounds. He became acquainted with the discoveries of Pasteur and certain other experiments, and applied them to wounds. There had been experiments in filtering air through cotton; Pasteur used gun cotton and dissolved it, finding then that it had caught spores and "animalculæ." Lister saw at once that if this were true, the key to the whole surgical situation would be, simply to keep these things out of the wounds.

Surgery was naturally out of fashion before 1846. It was both dangerous and painful and the most rapid work was best esteemed. In the demonstration of ether as an anæsthetic at the Massachusetts General Hospital, in 1846, however, it seemed as if surgery was to have a much more important place, but for a time anæsthesia actually made the situation worse. There was less pain and more surgery, but not more saving of life.

This was the situation when Lister caught the great idea. At about this same time carbolic acid was introduced, and Lister began then his antiseptic treatment, the killing of the germs. He made one error, for the belief was that

the germs were chiefly in the air. Lister sprayed the air, but did not at first know of the dangers from fingers and tools. His work was antiseptic, killing of germs in wounds, a work in the curative line. From it has grown the aseptic method, the keeping out of germs, or the line of prevention. The world has since seen the triumph of aseptic surgery, a sure foundation on which rests today the most brilliant section of therapy.

Some are inclined to decry Lister and rate him merely a follower of Pasteur. The true position is that taken by an eminent English authority, who finely said of him, "But though Lister saw the vast importance of the discoveries of Pasteur, he saw it because he was watching on the heights:—and he was watching there alone."

"Pasteur, next to Darwin," said Doctor Sedgwick, in conclusion, "was the greatest man of the nineteenth century, and after Pasteur should always be placed Robert Koch the German and Joseph Lister the Englishman, for these three were the founders of micro-biology, modern medicine and modern surgery."

STRUCTURAL STRENGTH OF PLANTS

The ability of certain plants to maintain an erect attitude in spite of excessive slenderness is truly remarkable. A stalk of rye, for example, may commonly attain a height of five or six feet, with a diameter at the base of only one tenth of an inch, a ratio of 500 to 1. Compared with such figures the slenderest man-made structures appear short in proportion to their height. The loftiest chimneys seldom reach a height of twenty times their diameter, and to meet the proportions of the rye straw and retain its present height, the Washington monument would have a diameter at the base of but thirteen inches. The disproportion is all the more startling when we consider that the rye stalk has further a very considerable weight of grain to support at its summit.

This remarkable stability of plants is due in part to a specialized system of extremely tough tissue comparable to the steel framework of a modern building. Careful measurements have shown this tissue to have a sustaining strength equal to that of the best wrought iron, while its ductility is ten or fifteen times as great. Not only is this material inherently strong, but its arrangement is such as to render it structurally most effective. The constructions are often extremely ingenious, and are a pretty example of the adaptation of the plant body to the requirements of its environment.

F. S., JR.

IMPROVING THE MERCURY VAPOR LAMP

The difficulty with the old form of carbon arc lamp has been the cost of the renewal of the carbons and the bother incidental thereto. Various forms of arcs which require no renewal have been proposed from time to time. Of these the best known is the mercury vapor arc. This, however, is not popular on account of the ghastly light which it gives. By raising the temperature of the arc, it is possible to get a luminous yellow light which is very pleasing. The glass tube which contains the mercury, however, melts at these high temperatures. Recently a quartz tube has been perfected which enables the necessary high temperature to be attained in order that the light may be yellow. This gives a very pleasing light. This arc lamp requires no attention except in case of actual breakage. It is stated that some fifty of these are in use in France and that one is in use in this country. L. E. M.

The Navy Department has a plan for a chain of wireless stations which will bring it into communication with battleships wherever they may be located. The chain includes a station at Arlington, Va., San Francisco, Cal., Pearl Harbor, Hawaii, the island of Guam, the island of Luzon in the northern Philippines, and Tutuila Island, one of the American Samoan group. Each of these stations will be equipped with a 100-kilowatt generating apparatus, and each will have a sending and receiving radius of 3,000 miles.

SCIENCE CONSPECTUS

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A GIGANTIC ENGINEERING UNDERTAKING

HOW THE PROBLEM OF SUPPLYING NEW YORK WITH WATER HAS BEEN SOLVED. UNPRECEDENTED SIZE AND CONDITIONS MAKE IT A PIONEER ENDEAVOR

Smithsonian Institution JUL 22 1915 Astrophysical Observatory

BY FRED F. MOORE

THE water now supplied to our greatest city comes from both surface and underground sources, mostly owned by the municipality. These sources, together with the ultimate capacities, are as follows:

Source.	*Ultimate Capacity Million Gallons Daily.*
Croton system supplying Manhattan and most of the Bronx	335
Bronx and Byram system supplying part of the Bronx	20
Ridgewood system supplying most of Brooklyn and Municipal supply in Queens	155
Private water companies supplying parts of Brooklyn and Queens	30
Staten Island system supplying Richmond boroughs	10
Total	550

The Croton system is a surface supply developed by some ten artificial storage reservoirs and many natural lakes and ponds, over some of which the city has control. These reservoirs and ponds, controlled by the city, have a combined available storage capacity of about 100,000 million gallons on a watershed of 360 square miles. The latest of these reservoirs to be constructed has been empty since its completion two years ago, the dry weather not having furnished enough stream flow to fill it.

Water from the Croton watershed is brought into the city through the old Croton aqueduct of 90 million gallons daily capacity, finished about 1842, and the new Croton aqueduct of 290 million gallons capacity completed in 1890.

The Bronx and Byram system is a surface supply obtained in 1884, the water being delivered to the city through a 48-inch cast-iron pipe. Lake Kensico, the lowest storage reservoir of this system, is now being superseded by the new Kensico reservoir of the Catskill system which will flood the margin of the old lake to a depth of over 100 feet.

The Ridgewood system is a combined surface and underground supply which has been gradually extended eastward on Long Island to the Suffolk County line, where further development has been stopped for the present by legal proceedings. Water is conveyed to the city through the Ridgewood masonry aqueduct of about 66 million gallons daily capacity, and through several pipe lines.

The water supplied by private companies in Brooklyn and Queens is ob-

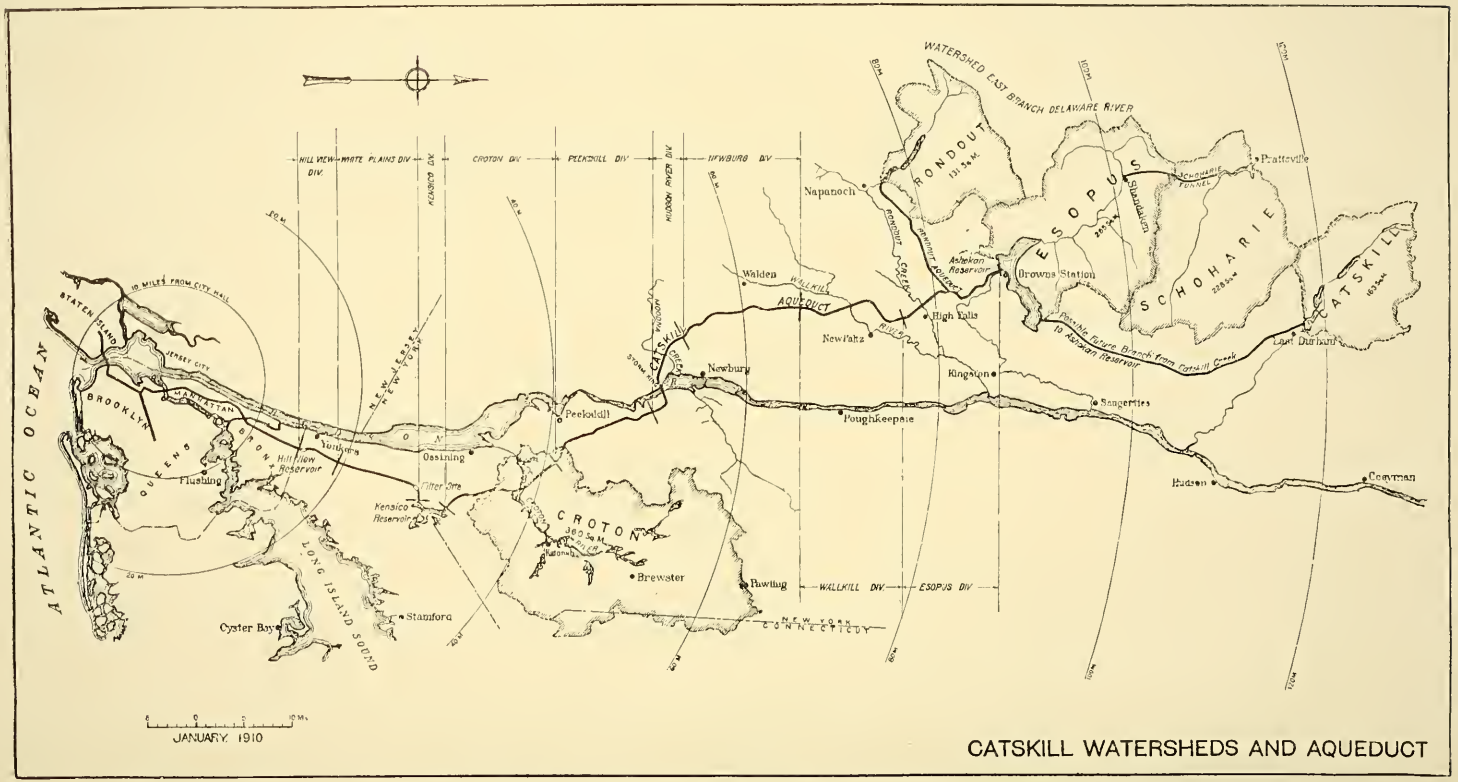

Fig. 1. Catskill Water System. Watersheds and aqueduct. Shows also the Croton watershed, the principal source of present supply; the Bronx and Byram watersheds are immediately adjacent to the Croton on the south

tained entirely from wells. These privately owned water systems are small; the largest, supplying part of the Flatbush section of Brooklyn, furnishing about 12 million gallons daily. The Staten Island system is a driven well supply unsatisfactory both in quantity and quality.

Rainfall is the source of all water supply, and other things being equal the smaller the rainfall for a given period, the lower will be the water supply. As a rough approximation about one half of the total rainfall in the vicinity of New York is evaporated either directly into the air or through vegetation: the other half goes into stream flow either directly by run-off from the surface or indirectly by underground movement.

To fully develop a surface supply, it is necessary to have storage capacity sufficient to hold the flood flows, to tide over the period when the natural stream flow is low, in order that water accumulated irregularly from precipitation may be used at a comparatively uniform rate. For the ground water supply, this equalizing storage capacity is provided in the pores of the subsoil. It is evident that in neither case can more water be drawn off than reaches the place of storage. Experience has shown, for example, that with the driven well system on Long Island the attempt to pump too much water results in the gradual lowering of the ground water level, and the drawing in of salt water from the ocean by reversal of the normal ground water slope.

All of the present supplies for New York City are developed fully up to their reasonable capacity. Irresponsible statements have frequently been made that it is a waste of money to construct the Catskill system, because the water that was wasted over the spillway of the new Croton dam during the exceptional flood flows in the winter of 1907–08, might have been saved by the building of more reservoirs in the Croton watershed. Records of stream flow of Croton River since 1868 show that it would be necessary to provide a reservoir capacity nearly four times as great as that now existing on the Croton watershed at a cost of something like $150,000,000, in order to prevent any water from wasting over the spillway of the new Croton reservoir during the forty-year period from 1868 to 1907, while the supply added by this means would be less than 50 million gallons daily. To compare with this, the Catskill supply will furnish more than ten times this quantity of water at an estimated cost of $162,000,000. The eighteen years from 1869 to 1886 gave an average daily flow of Croton River of 346 million gallons per day, while the following eighteen years from 1887 to 1904 showed a corresponding flow of 449 million gallons per day, nearly one third more. These later years of high stream flow, so long continued, tended to make one forget the probability of a recurrence of the conditions of low flow which are apparently now upon us. During the summer of 1911, the Croton reservoirs were very low, and would have been lower but for the success of decisive measures taken to reduce the consumption of water. If the conditions of the dry eighteen-year period were to be exactly repeated now, an estimate shows with reasonable allowance made for a normal increase in total consumption of water due to growth of population, there would never be any more water wasted over the new Croton dam, until the situation was relieved by the bringing in of another supply.

Within less than ten years after the completion of the new Croton aqueduct, it became evident to competent students of the situation that the increasing use of water due to the rapid growth of the city was making existing sources of supply really an unsafe reliance in spite of the apparent adequacy resulting from the then abnormally high rainfall. As far back as 1896, the problem was considered by the Manufacturers Association of Brooklyn. In 1899, Comptroller Coler brought about an investigation of the available sources by Consulting Engineer John R. Freeman, M. I. T., '76. In 1901, following this agitation, a bill was introduced in the legislature, looking to the creation of a commission empowered to add to the water supply of the city. Still later, in 1902, Commissioner of

Water Supply Robert G. Monroe appointed the Burr-Hering-Freeman Commission to investigate the question.

As a result of all these studies, the legislature on June 3, 1905, under chapter 724 of the laws of that year, authorized the work now being carried out by the Board of Water Supply. Mayor McClellan on June 9, 1905, appointed the first members of the board from three lists of three names each submitted by the Chamber of Commerce of New York, the Manufacturers Association, and the Board of Fire Underwriters. These commissioners, J. Edward Simmons, Charles N. Chadwick and Charles A. Shaw were confronted with the task of determining sources of supply from which water was to be taken, the location and equipment of offices, and a thousand and one details involved in establishing a great enterprise for delivering and distributing to the metropolis five or six hundred million gallons of water daily.

As eventually perfected the organization is divided into three bureaus,—administration, engineering and police. Of the administration bureau, the secretary, auditor, chief clerk, adjuster of taxes and assessments and examiner of real estate and damages, with their staffs aggregating 100 perform the duties designated by their titles. A police bureau under an inspector comprises 80 sergeants and 270 patrolmen for policing the territory in which construction is carried on, enforcing sanitary measures imposed by the board through its contractors upon their employees and through its mere existence furnishing moral protection to local communities.

The engineering bureau comprises on the staff of the chief engineer, J. Waldo Smith, M. I. T., '87, appointed August 1, 1905, a deputy chief engineer, a department engineer as personal assistant, and four consulting engineers. The general force is under five other department engineers.

Headquarters department has in charge the preparation of designs and specifications, the inspection of construction materials before delivery, technical experiments, and investigations and general administrative matters involving personnel, supplies and equipment. Reservoir department is charged with all surveys and construction in the watersheds. To Northern Aqueduct department was assigned field investigations, surveys and construction of a sixty-mile stretch of aqueduct from the Ashokan reservoir across the Hudson River to the Croton watershed. At this point the territory and work apportioned to Southern Aqueduct department begins and comprises the Kensico and Hill View reservoirs, thirty miles of aqueduct and the proposed Eastview filters. City Aqueduct department is supervising construction within the city limits.

Experts in specialized lines, such as geology, filtration, landscape work and sanitation of camps are engaged as needed.

In headquarters department there is an executive division upon contracts, statistics, reports and general executive duties, a designing division, preparing plans, specifications and working drawings, an inspection division with headquarters at the testing laboratory and assistants in various factories and cement mills, and a real estate division to prepare estimates and agreements with property owners and maps, and descriptions of lands required.

The four field departments are each also divided into an executive and a number of other divisions, and these in turn into sections, each responsible for an aqueduct length of three or four miles representing $1,500,000 or $2,000,000 of construction; some sections supervise reservoir contracts of still larger amounts.

At the height of activity of this great work, there are more than one thousand employees in the engineer bureau, including engineers and engineering assistants of all grades, clerks, stenographers, laborers and gage keepers.

Immediately upon his appointment, the chief engineer assembled a small force, and began study of the engineering problems, while working out the organization and equipment for the work ahead. This study was prosecuted to such good purpose that on October 9, 1905, the Board of Water Supply submitted for

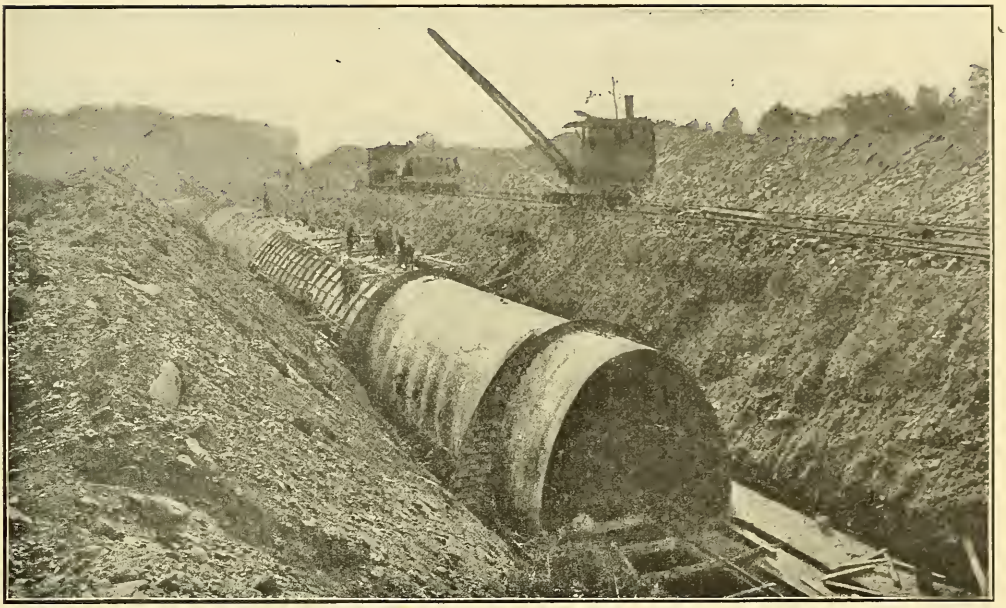

Fig. 2. Catskill Aqueduct. Typical cut-and-cover construction in open cut; completed invert in foreground, followed by interior and exterior forms; completed arch and refilled trench. Locomotive crane depositing concrete brought by dinky train from concrete plant in distance

approval to the Board of Estimate and Apportionment, a plan for obtaining from the Esopus, Rondout, Schoharie and Catskill creeks a supply of not less than 500 million gallons daily at an estimated cost of $161,857,000.

The preliminary surveys and investigations proceeded rapidly from this time on. As the Hudson River crossing was a primary controlling point in the aqueduct alignment, borings were early started at several places in the Hudson River. More than 200 borings were made on fourteen cross-sections between Pegg's Point and Storm King, a distance of about fourteen miles. The early work, including study of aqueduct alignment on both sides of the river, resulted in soon fixing attention quite definitely on the Storm King-Breakneck crossing, and efforts were directed toward developing the shape of the gorge and the character of the rock at this place. It early became evident that rock was at such depths in the gorge, certainly more than 600 feet below the river surface, that adequate investigation by borings from the river surface alone would consume too much time. The material over the rock is penetrated by the wash rig. This is a device of two iron pipes, one within the other, with the necessary machinery for churning the inner one, while a stream of water under sufficient pressure is forced through it to the bottom, and up again in the annular space between them to the top, carrying up by the force of the current the displaced sand and clay. As progress is made in churning down the inner pipe, the outer one, or casing, is driven down from time to time. With this outfit was used at times, a heavy chisel-shaped plunger within the casing, which, actuated by machinery, chopped up or displaced the larger obstructions in the way of the casing. The diamond drill used to penetrate rocks, including boulders encountered in the wash rig borings, consists of a steel bit around the edge of which is set black diamonds. By rotating this bit, a circular cut is made in the rock, and a cylindrical core somewhat smaller than the inner diameter of the bit, detached. By the use of suitable tools, this core when from good strong rocks may be brought to the surface in considerable lengths for examination and study. By proper attachment to jointed

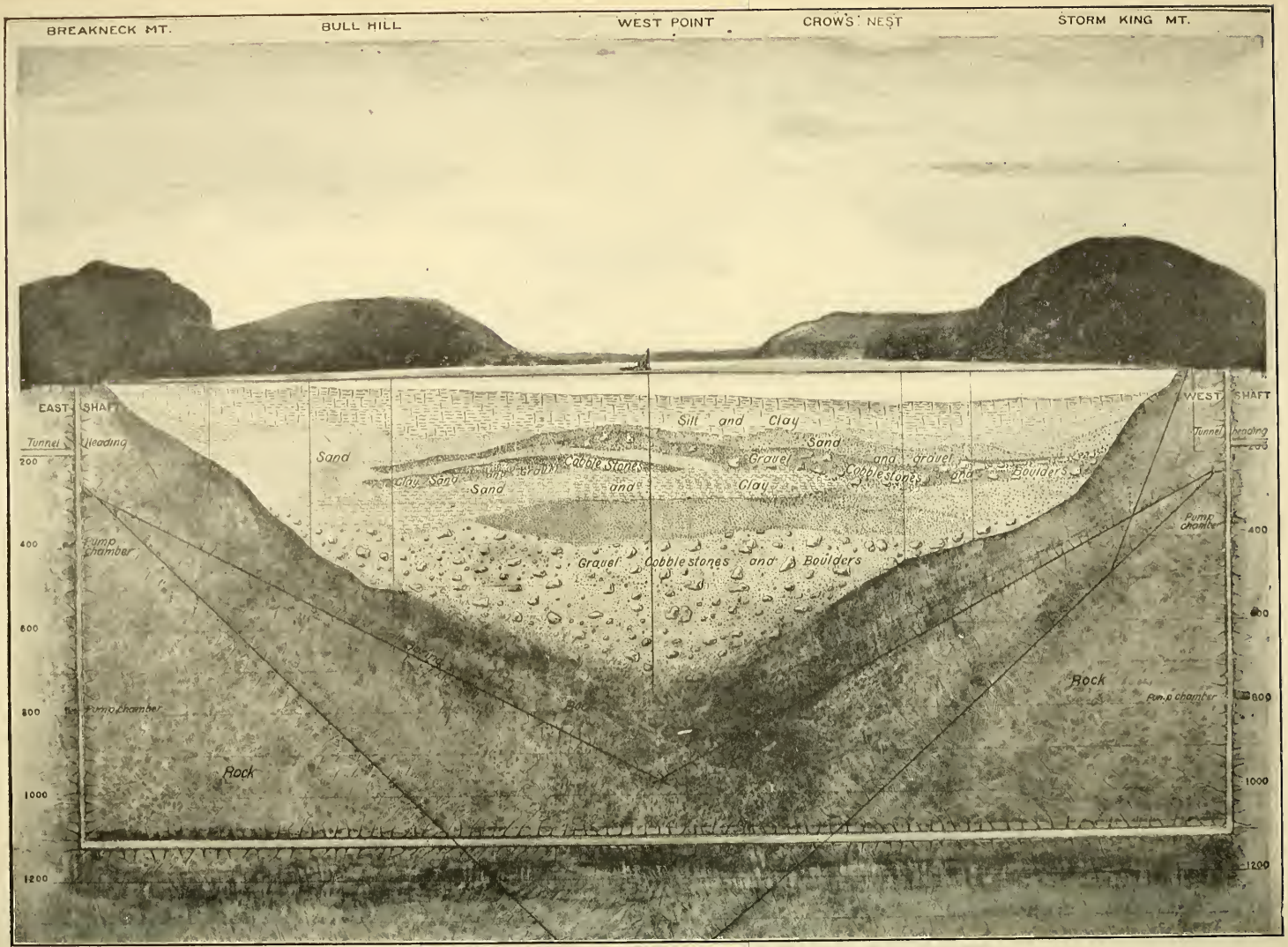

Fig. 3. Catskill Aqueduct. Hudson River siphon. Test shaft on each side of the river which will be a part of the permanent waterway. Inclined and vertical borings with drill rig on the river. Excavation of tunnel completed January 30, 1912

tubes, the diamond drill may be used for boring also inclined holes in rock. The complex character of drift filling in this river gorge, with numerous intermixed boulders, made it necessary to reduce the size and recase the holes frequently. Some of the later borings were started with eighteen-inch casings, in order to make possible the necessary reduction in size, as the depth increased. The work also suffered largely from the menace of river traffic. Several times after holes had been slowly and with great effort pushed deep into the drift an unmanageable or carelessly handled steamer or scow collided with the drilling outfit, and the hole was lost. Accordingly, it was decided to sink a shaft on each side of the river, designed to become eventually a part of the aqueduct, unless the rock conditions were found unsuitable for a deep pressure tunnel. Agreement for this was executed in February, 1907, and during the calendar year shafts were excavated to a depth of about 250 feet, when the work was abandoned by the contractor. After the unfortunate delay occasioned by this complication, shaft sinking was resumed by the Board with its own forces. As soon as the shafts had reached sufficient depth, about 300 feet, inclined diamond drill holes were started towards the river from drill chambers excavated in the sides of the shafts. The first pair of these holes was inclined at an angle about forty-five degrees to the horizontal. These borings were continued until they crossed near the middle of the river almost 1500 feet below its surface, requiring a length of nearly 2,000 feet for each hole. A second pair of holes was drilled from the same chambers, but at an angle of twenty-three degrees with the horizontal. These holes about 1650 feet long terminated near the middle of the river about 960 feet below the water surface. These holes were all in granitic gneiss, and comparatively little water was encountered. While this boring was going on, consistent progress was made in shaft sinking. An interesting phenomenon developed when the shafts had reached a depth of about 800 feet. The rock, although sound and hard, would spall from the sides with a loud noise and sometimes in considerable masses. This "popping" of the rock became more frequent and dangerous as the depth increased, and it was finally necessary to substitute steel lining for the timbering ordinarily used in such work. The "popping" appears to result from the removal of support, through the excavations, from rock masses which at these depths were highly stressed.

The completion of the diamond drill borings, defining as they did a zone within which the character and condition of the rock was felt to be pretty definitely known, permitted fixing the elevation of the tunnel at about 1,100 feet below the river surface. The shafts were sunk by the board's forces to the elevation of the tunnel headings and several hundred feet of tunnel excavated from each shaft, when a contract for the remaining work was let in June, 1911. The work was prosecuted by the contractor to such good purpose, working from both shafts, that a small quantity of rock intervening between the two headings was shot away when Mayor Gaynor pressed a button at the simple, but impressive, ceremonies at the opening of the tunnel January 30, 1912. Thus was brought to a successful conclusion that part which has been more discussed than any other, especially in the way of adverse criticisms by ill-advised critics.

The determination of the final location of the aqueduct, involving investigation of sub-surface conditions under several other deep valleys, in general required a careful investigation of many alternative lines, and their study with reference to the cost of the structure, and its ultimate security and other factors of topography, geology, accessibility and the availability of construction materials, especially of concrete aggregates. There are four principal types of aqueduct structure, standing as follows in order of cost per linear foot, beginning with the cheapest construction; cut-and-cover, grade tunnel, pressure tunnel and steel pipe siphon. As finally located as much as reasonably possible of the line is of cut-and-cover concrete aqueduct on account of its rela-

tive cheapness. In the same way whenever the geological conditions are suitable, valleys are crossed by pressure tunnels deep in the rock; this type being cheaper than steel pipe laid at or near the surface.

The total fall available for producing flow in the aqueduct is distributed among the different types of construction in inverse ratio to their cost per linear foot. Thus the greatest fall or slope per unit of length is given the most expensive type, the steel pipe siphons, that the size, and hence the cost may be properly balanced. In the same way each type has been given a slope consistent with its cost, the smallest slope being that of the cut-and-cover construction as it is the cheapest. The gradient is further adjusted by increasing the slope at the upper end to compensate for a decreased carrying capacity which would otherwise obtain through greater fouling of such aqueducts near the headworks.

The design of these works on account of their unprecedented size was in many of its phases pioneer endeavor. The effect of temperature changes upon masonry had to be very carefully considered in these water works structures where leakage is of such importance. A careful consideration of the corrosion of metals led to the considerable use of bronze and other non-corroding alloys for these works which must be designed to give long and continuous service.

For controlling, screening and measuring this river of water some sixty gate, screen and gaging chambers are required. Eight of these structures, for primary control, and for screening, are of great size; the superstructure of the largest gate chamber, one of those at the Ashokan reservoir, is about 50 feet by 140 feet. In these structures are many large sluice gates and gate valves which are among the most interesting of the mechanical engineering problems. Some of the gates operate under more than 100 feet head. The largest of the sluice gates are 6 feet by 15 feet, and weigh more than eighteen tons. Aërators are to be constructed at the outlets of both the Ashokan and Kensico reservoirs for treatment of the water when desirable. These aërators will be very interesting fountains of unusual size, each having almost 2,000 nozzles of discharge area three times that of the fire nozzles ordinarily used. In connection with the construction of the Ashokan reservoir, about thirteen miles of railroad is to be relocated, and in the watersheds and along the aqueduct many miles of new highway must be constructed.

Expedition work for any one of the contracts into which the undertaking is divided is alone, as distinguished from the permanent construction, an activity of magnitude. Before any considerable progress on permanent construction can be made, railroads must be built, power plants erected, power, light and telephone wires installed, and pipes laid for water supply and sewerage and in some cases, pipes for compressed air transmission. For some of the work, notably the longer tunnels, the central power plants become very pretentious undertakings.

The contracts of the board are painstakingly drawn to prevent danger to health of communities and individuals, including the men engaged in construction, which might result from the presence of many workmen, mostly illiterate, and unused to even ordinarily good standards of living and cleanliness. All along the line, the contractors are bound to protect public and private water supplies. Good buildings for housing the workmen, suitable stables for animals and ample and well-equipped hospitals, all located under expert supervision, are required. Supplies of water ample in quantity, and of suitable quality for all purposes must be provided. Collection and disposition by incineration, or other suitable means, of human wastes and garbage is insisted upon.

Within the limits of the Croton and other important water-sheds, through which the southern portions of the aqueduct passes, the sanitary regulations and measures are even more rigid. Each of these camps is a community in itself, sometimes isolated by a man-proof fence, and is, in addition to the above-mentioned features, which are general,

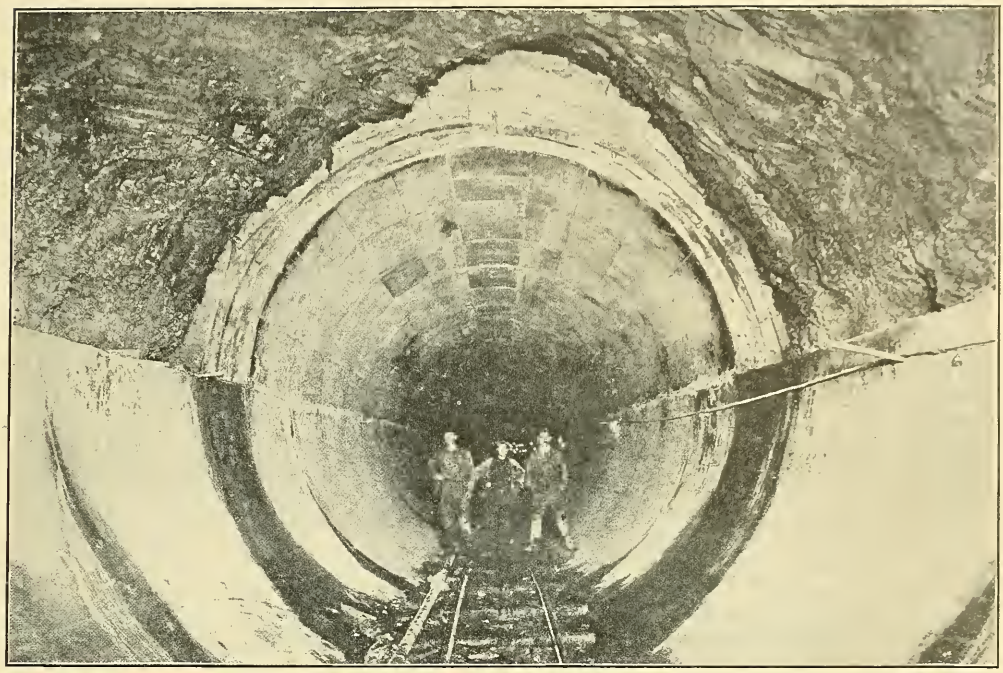

Fig. 4. Catskill Aqueduct. Rondout pressure tunnel, 14 feet, 6 inches diameter. Excavation in Hudson River shale and finished length of concrete lining; grout holes visible in arch keys. Other pressure tunnels, including Hudson River crossing, differ somewhat in size; but are similar in shape and structural details

provided with special disposal works for treating camp sewerage and drainage. These disposal works, in general, consist of a filter plant into the effluent of which a suitable quantity of hypochlorite of lime solution is added to effect a high degree of disinfection before the water passes into the nearest water course or lake. These filter plants in some cases treat also tunnel drainage and run-off from spoil banks. In some cases, it is deemed better to treat the whole flow of the stream with hypochlorite of lime by means of a dosing plant, consisting essentially of a solution tank and apparatus designed to automatically proportion the dose to the quantity flowing in the stream. The effective control of sanitary conditions is imperative on account of the magnitude of the work, and the vast number of people who otherwise would be exposed to real danger, imposing upon the city moral and legal obligations which have been met in an unprecedented and thorough manner in the work of the Board.

A brief description of one of the largest camps will illustrate the working out of this part of the problem. The construction of the Ashokan dams requires an army of about 3,000 men who live, many with their families, in a camp built by the contractor near the work. Italians and negroes live in separate sections. There have been provided sewerage and water supply systems, a special plant for the disposal of sewage, good dwellings, generally one-story wooden structures, with screens on doors and windows, well-lighted streets, electric lights, telephones, a savings bank, hospital, general store, bakery, police organization, fire protection, and a kindergarten and schools for children. An evening school for men is one of the features of the camp. An eight-hour day gives plenty of time to attend the school where the English language and the elements of national, state and city governments are taught. These camp-schools were instituted by the commissioners personally, and have been supported by private subscriptions with the assistance of the contractors. Besides the main camp-city, there are

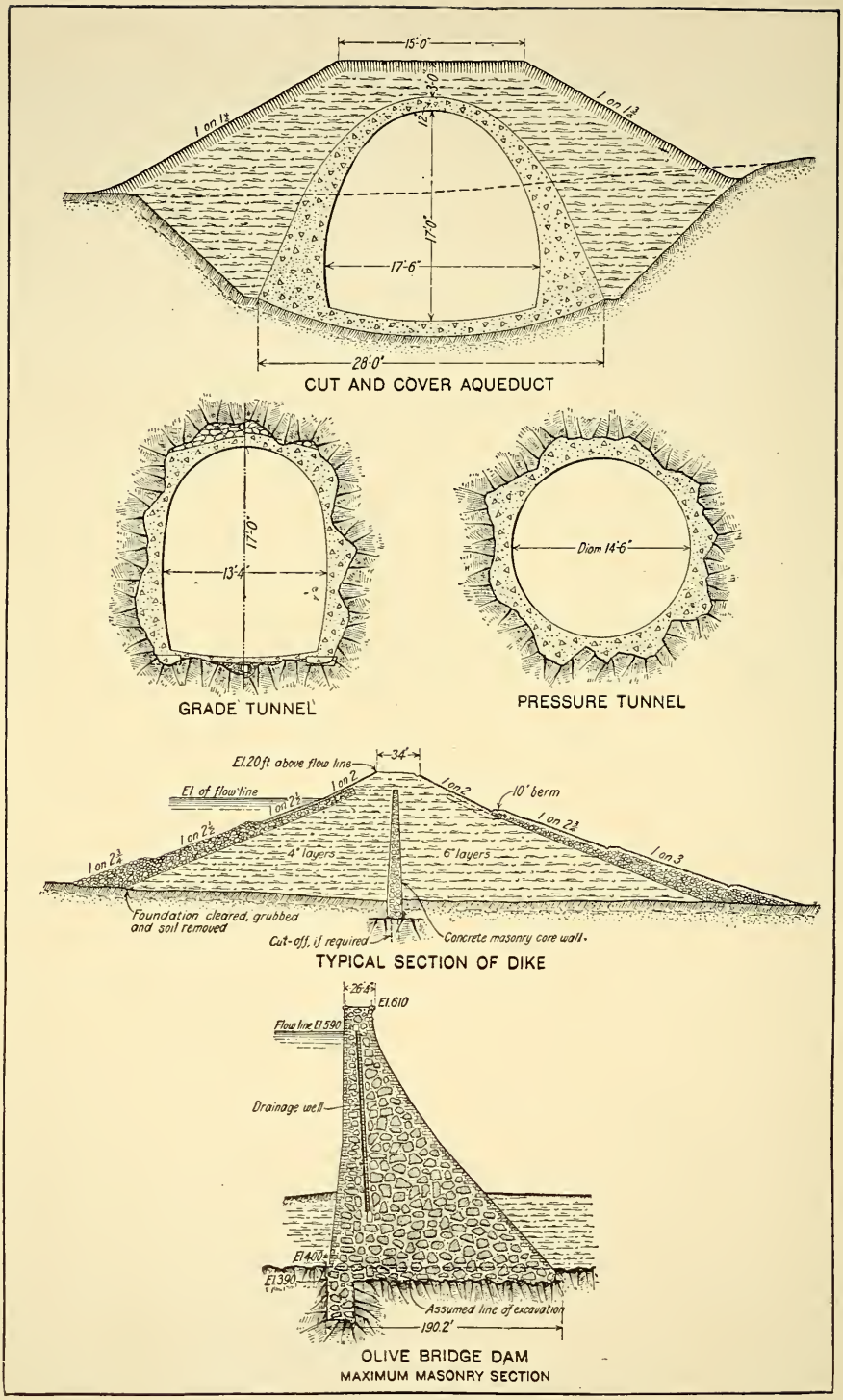

Fig. 5. Catskill Water System. Some typical structures

smaller camps in outlying parts of the reservoir work.

Throughout the work attention has been given to so treating the permanent structures and the spoil that the operations will result in blending the work with the general features of the country, so as to make pleasing pictures at all conspicuous points instead of the eyesores which have been so often created by public works. To this end, extensive planting and forestry operations are planned, and desirable existing growths are protected as far as possible. Nurseries for the propagation of forest trees are already established. The scarcity of top-soil in some places along the aqueduct presents a considerable problem in obtaining and maintaining growths sufficient for protection of earth embankments. Experiments already made to determine suitable grass mixtures for various soil conditions give promise of satisfactory solution. Rock embankments and spoil dumps may be screened and beautified by a covering of vines growing in pockets of earth.

The first construction for eleven miles of aqueduct was awarded in March, 1907. In the three years following, contracts aggregating more than $70,000,000, for the reservoir work and all of the aqueduct down to the city line, were prepared and awarded. Up to the end of 1911, nearly $45,000,000 had been earned upon contracts in force, and construction was so advanced that it is probable water can, if necessary, be delivered from the Catskill Mountains into Croton Lake about the end of 1912. At the periods of most active construction during the past two years, about 16,000 mechanics and laborers have been employed by the contractors, and it is not anticipated that the force for the coming year will vary greatly from this. Some particularly noteworthy progress has been made: In October, 1909, a quantity of masonry exceeding 33,000 cubic yards was placed in Olive bridge dam; in September, 1910, the excavation of one of the headings of the Wallkill siphon was advanced 530½ feet which is believed to be the world's record for hard rock tunnel.

And so with such a large part of this great enterprise achieved, it may be felt that we are measurably approaching that end which Mayor McClellan had in mind when he said at the inauguration of construction June 20, 1907, ". . . when this great work, conceived in honesty, begun in honesty, and God willing, completed in honesty, shall be ministering to the health and the happiness of millions yet to come, then

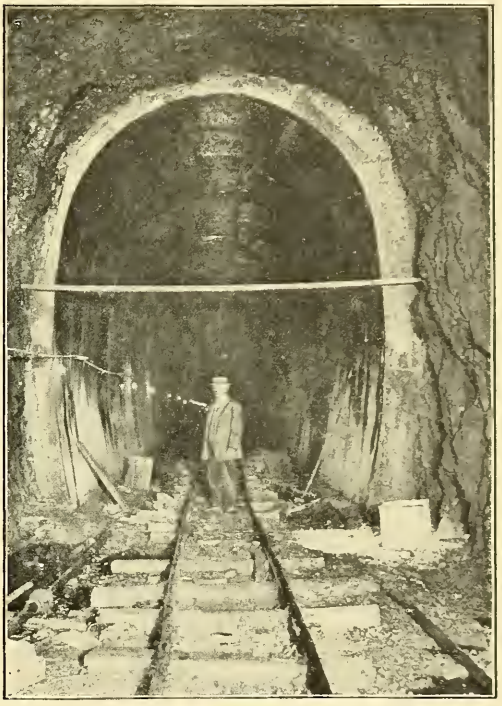

Fig. 6. Catskill Aqueduct. Bonticou grade tunnel, 17 feet high, 13 feet, 4 inches wide. End of completed arch lining

God grant that those who shall see it in the distant years may say—it does not matter how they were called who did this thing, or who they were or what they were: it is enough to know that they did their duty."

The Board of Water Supply which is building the Catskill works consists of three commissioners, Charles Strauss, Charles N. Chadwick and John F. Galvin, the first named, president.

THE FOURTH DIMENSION AS A TEXT

THE REALM OF ANALOGY WHICH IS STORED WITH CREATIONS OF MATHEMATICAL IMAGERY USEFUL ONLY TO THE SCIENTIST IN CORRELATING PHENOMENA

BY E. B. WILSON

To ATTEMPT to write a popular article on any scientific subject is taking one's scientific reputation rather lightly. For the things that are interesting are not true, and the things that are true are not interesting. The reason for this is that sane scientific truth lies not so much in facts as in points of view. The popular reader, be he never so well educated, is apt to be expectant of some startling fact and impatient of a qualified point of view.

Contrary to Newton's famous "hypotheses non fingo," the scientist is always making hypotheses, setting up theories, formulating models of one sort or another, to aid him in correlating known phenomena and to suggest to him new relations. Some of these hypotheses are wildly speculative, some of the theories are largely mathematical, many of the models are exceedingly gross and admittedly far removed from reality. All of these, in their interesting details, are temporary rather than permanent.

The reader who wishes to experience thrills (or the editor or writer who wishes him to) may revel in the wild hypothesis or gloat over the crude model with a feeling of satisfaction that he is up to date in science; and yet he may actually be getting further from the position of the true scientist than if he had never dabbled with these matters, unless he bears constantly in mind the vital point of view that hypotheses are only good, theories are only useful, and models are only valuable first, in so far as they are serviceable in correlating phenomena, and second, in so far as their manner of failure to correlate other phenomena may be suggestive of advisable changes in them.

Such a statement as this needs particularly to be emphasized by publications of general circulation like SCIENCE CONSPECTUS and *Popular Science Monthly*.

Apparently the fourth dimension is a subject of feverish popular curiosity. If a young lad, precocious in mathematics as in other things, discovers for himself a few theorems in four dimensional geometry, well known and evident to the trained mathematician, he is headlined all over the country as revealing new and marvelous doctrines to our learned geometers; and the interest in the fourth dimension becomes even more breathless. And yet, when regarded scientifically, the subject is uncommonly devoid of possible popular interest.

Mention the fourth dimension to a class of freshmen or sophomores, and the response is immediate though not unanimous; some listen reverently with bated breath, others smile incredulously and derisively. Both attitudes are wrong; we are not in the presence of a marvel or a fake, but merely witnessing the two habitual manifestations of ignorance, fright and persecution. The other topic that produces similar, though less marked symptoms in a class of undergraduates is "infinity," which for the mathematician is a subject much more interesting and difficult and necessary than the fourth dimension.

Some, if not most, of the blame for the wrong attitude of the public toward the fourth dimension must be laid at the door of mathematicians who have written on the subject for popular consumption. It is particularly true here that what is interesting is untrue and what is true is uninteresting. To be interesting is essential to the publicist. Hence the eclipse of truth

As, however, I am resolved to be as truthful as possible, I am indifferent to being deadly dull.

In the analytic geometry of the freshman year, and nowadays often in the algebra of the high school, the student learns to interpret the linear equation

$$ax+by+c=0$$

as a straight line. He learns that the solution of two such equations represents the point of intersection of the corresponding lines, and that the algebraic condition that the two equations cannot be solved simultaneously is equivalent geometrically to the statement that the lines do not meet, that is, are parallel.

In algebra he is also familiar with the linear equation

$$ax+by+cz=d$$

in three unknowns, and knows that ordinarily three such equations can be solved simultaneously. In solid analytic geometry he learns that the linear equation represents a plane, and that the algebraic solution of three simultaneous equations is equivalent geometrically to finding the point of intersection of three planes.

The correlation between the algebraic and geometric statements may be pushed a long way. Thus, if the three planes are parallel to a line so as to form the faces of a triangular prism, instead of a triedral angle, the planes have no point in common; the equations would then have no simultaneous solution. On the other hand, if the planes all pass through a line, they have an infinity of points in common; algebraically the three corresponding linear equations have an infinity of simultaneous solutions instead of merely one.

It must be apparent that a great deal of interest is added to the algebra of linear equations in two or three variables when the equations are interpreted as lines or planes as the case may be. Now suppose one had to deal with an equation

$$ax+by+cz+dw=e$$

in four unknowns. Here no geometric interpretation appears evident. For if we would represent a set of values (x, y, z, w) of the variables as a point, in a way analogous to our former representation of (x, y) or (x, y, z), we should have to have four dimensions. Now we do not have four dimensions. Hence we cannot make any such pictorial representation.

It may be, however, that we have become so thoroughly accustomed to speak of the pair of values (x, y) as a point in the plane and of the linear equation in x, y as a line, and of the triad of values (x, y, z) as a point in space and of the linear equation in x, y, z as a plane, that we cannot give up the geometric method of speaking. Thus we go right on talking with geometric words, saying that the set of values (x, y, z, w) is a point and that the linear equation in x, y, z, w is a planoid. But we should clearly recognize that if we do this, we are no longer speaking geometrically in the strict sense of the word, but merely analogically, because we have not four dimensions in space.

Powerful is the grip of figurative language. If we use analogy enough, we will find ourselves coming to believe in the existence of the analogue. By talking long enough as if there were four dimensions, we come to the belief that there are four. If we have to deal with equations in five or six or ten unknowns we shall likewise come to talk of, then to believe in, five or six or ten dimensions. The fact that we are merely talking words of which we have no very keen visualization does not bother us very much; we are accustomed to it in our discussions of art, economics, literature, politics, education, and everything else, to such an extent that it is no serious inconvenience in mathematics. It is faith not reason that brings action; we fight for catch-words and mottos, we arbitrate reasons.

Although the first stage of our use of four or more dimensions may thus be rather loose and vague analogy, we may reach a second stage by inverting the relation between algebra and geometry. Whereas we began in the two simpler cases by interpreting the algebraic elements as geometric elements in plane or space, we may now define the geometric

elements of higher dimensions in terms of the algebraic. Thus by definition a set of values (x, y, z, w) shall be called a point in four dimensional space, and by definition the said four dimensional space shall consist of the totality of such points or sets of values. Persons who desire to avoid the use of the term space in this connection often employ the word manifold.

We may carry our definitions further. The totality of sets of values (x, y, z, w) which satisfy a linear equation in x, y, z, w, may by definition be said to form a planoid. The values $(x, 0, 0, 0)$, for varying x, will be said to trace the X-axis; the values $(0, 0, 0, w)$, for varying w, trace the W-axis. The equation $w = 0$ is said to be the planoid which represents the three dimensional space of x, y, z; the two simultaneous equations $w = 0$, $y = 0$ represent the plane of x and z. And so on. Any person who knows the formulas for the distance between two points in two dimensions and in three dimensions will have no difficulty in extending those formulas by analogy to obtain the expression which by definition shall be the distance between two points in four, or in any number of dimensions; and so with a great variety of formulas in analytic geometry.

In this way we construct by definition a four dimensional space or manifold with all sorts of elements in it. This, however, does not imply the existence of any such space in a physical, as distinguished from a conceptual mathematical sense. It does not mean that the visualization of that space and the elements in it is any less vague than in the first stage of mere verbal analogy. The advance consists merely in the definiteness of a logical nature which has been gained by actually giving the definitions. Instead of believing in some undefined fourth dimension in which we are interpreting our algebra, we see clearly that our so-called space of four dimensions is really defined from our algebra.

One might readily ask: What use is this space thus defined? How by mere definition from algebra can one obtain a geometry that contains anything more than was contained originally in the algebra? Logically you do not obtain anything new; analogically you have perpetuated a graphic phraseology which may suggest, by analogy, certain relations which would not so readily be suggested by the purely algebraic form of statement. And this is precisely the use of the space that has been defined. Logic is only the prose of mathematics; imagery is its poetry, and there is often more inspiration in a vague impressionistic poem than in the clearest prose.

We have spoken of the algebraic derivation of the fourth and higher dimensions. This was perhaps the first, it is undoubtedly the most developed aspect of the subject. Long treatises, intelligible only to the professional mathematician, have been written about it. Here at the Institute within a year Professor C. L. E. Moore and Doctors H. B. Phillips and J. Lipke, of our mathematical department, have published original investigations concerning higher dimensions, and some years ago I did as much myself. It is a thoroughly creditable field of research in pure mathematics—not in physics, nor in psychics.

We must not altogether omit mention of another point of view which, in contrast with the algebraic, may be called the logical or postulational method of constructing a geometry of higher dimensions. Let us first observe that we found plane geometry upon a certain (or perhaps a rather uncertain) set of axioms or postulates. When we come to study solid geometry we find a few additional or different axioms to complete the former list and adjust it to three dimensions. Now suppose that we lay down a set of postulates which is a sort of extension and alteration of our list for space in such a manner that the elements called points could not all be represented as points in three dimensional space. Then, if our list of postulates or axioms is free from self-contradiction, we can logically build up a geometry upon it as a basis.

For we must remember that although in two and three dimensions we actually draw figures and demonstrate our theorems from them, the real proof of the

theorem is independent of the figure and stands or falls solely by the perfection or imperfection of the logic by which the successive conclusions are drawn from the premises, and these premises are either previously demonstrated theorems or the axioms or postulates. Thus by pure logic we can build up a system of geometry for two and for three dimensions wholly without figures, provided only that our postulates suit the plane and space.

In a similar manner a number of non-Euclidean geometries have been built up from assumptions differing in one way or another from those of Euclid. Hence in this way, too, we could construct a four dimensional geometry. But here again we have no more a real physical space of four dimensions than we had from our algebraic point of view. As there it was all a question of definition from algebra, so here it is all a question of logical deduction from assumed propositions called postulates. In both cases it is a mathematical game that we play with the aid of geometric analogy; and we call it geometry because we use the language of geometry and feel the analogy so keenly that the analogue seems almost to attain objective reality.

We say seems almost to attain objective reality. For to the pure mathematician no more than to the man in the street is that reality attained. No one has any clear real visualization of a fourth dimension added to length and breadth and depth. It is the thorough training in algebra, the great facility in abstract logic, and above all a hypertrophied sense of analogy which enable the mathematician to thread his way safely through the mazes of four, and higher, dimensional geometry, even though those geometries are more complicated than ordinary solid geometry. For all that a mathematician may know about the fourth dimension he can no more get out of a closed box than can any one else.

What is the fourth dimension? There is none, in the sense in which this question is usually asked. Mathematically it is a sort of vague analogy, or a geometric phraseology applied to algebra, or a body of logical deduction. Not very exciting, all this.

The external space in which we live is geometrically three dimensional. Yet the world in which we move is in one sense at least four dimensional. For we need to know not only "where" but "when." We need not only the three coördinates (x, y, z) of position in our three dimensional space; we need also the additional variable t to denote the time. In order to specify the location of a particle in time and in space we have to attach to the particle four variables (x, y, z, t). We can therefore speak of this complete designation as a point in four dimensions.

Indeed in texts on mechanics in studying the motion of a particle on a straight line where the distance of the particle from a given point of the line may be represented by x and varies with the time t, it is often found convenient to plot the relation between x and t as a curve in a plane, the plane of the variables x and t. This curve is not the locus of the particle, which is moving in a straight line, but it serves to represent graphically the relation between distance and time. In a similar manner the motion of particles in three dimensional space could be represented by curves in the four dimensional manifold or space of x, y, z, t.

This may seem very artificial, and it can hardly be said to be useful in elementary mechanics, where the student has difficulties enough without worrying about four dimensional geometry. But it is worthy of note that from a mathematical point of view this representation of space and time in a combined four dimensional manifold or space forms the basis of the simplest statement of that new fundamental physical Principle of Relativity, which Professor Comstock has been explaining to readers of Science Conspectus. It is therefore not at all improbable that the time is close at hand when physicists, in addition to mathematicians, will have to become accustomed to the use of four dimensions. That is a question upon which Professor G. N. Lewis and I are hard at work.

GEOLOGY OF THE RHINE VALLEY

DESCRIPTIVE SKETCH OF THE FIVE GRAND GEOLOGICAL DIVISIONS OF THE RHINE EXTENDING FROM ITS SOURCE IN SWITZERLAND TO THE NORTH SEA

BY H. W. SHIMER

The course of the Rhine from its rise in southern Switzerland, through Germany and Holland, to the North Sea consists of five grand divisions. The Alpine division extends from the beginning of the Vorder Rhine on the heights east of Andermatt to Lake Constance, a distance of about 100 miles. It is here a small stream with numberless milk-white cascades and raging falls, running amid rocky defiles and fed by snow-clad mountains. The Great Swiss Valley division with a length of 100 miles from Lake Constance to Basel flows between comparatively low banks through a portion of the great lowland area of Switzerland. Its course is marked by few cascades and falls, the only one of note being the celebrated Falls of the Rhine near Schaffhausen. Since these falls were not mentioned by the Roman writers, who were familiar with this region, it has been suggested that the Falls were not then in existence, but that the river was then cutting through the loose glacial drift which filled the valley and reached the bedded rock of Jurassic limestone over which the river now falls only in post-Roman times. Thick deposits of glacial drift form part of the river banks from above the falls to far below them. Just above the falls the river has a width of 375 feet.

The third, or Graben division of the Rhine, extends from Basel to Mainz, a distance of about 200 miles increasing in width from 600 feet at Basel to 1500 feet at Mainz. It forms the handle of which the two earlier divisions are the hook in a very perfect figure five or button-hook. In this Graben division, to use the German term for a down-faulted block of the earth's crust, the Rhine flows over the top of the keystone which has fallen out of the elongate earth arch extending from Basel to Mainz. This keystone had an average width of twenty miles and over this flat surface the river only now meanders with not even a rapid to mar its even course. At the sides of this valley the hills rise quite suddenly to a height of 1000 to 1500 feet. As the northeastern continuation of this Graben has been partly filled with volcanic deposits the Rhine bends northwards over the region of the slate mountains, and into these rather level uplands it has cut a narrow gorge about 1500 feet wide and 500 feet deep. This, the fourth, or Gorge division, extends from Mainz to Bonn, a distance of about 100 miles. The river is here swift, with many rocks exposed in its bed. The scenery of this division is very celebrated; the river is bordered by precipitous cliffs for nearly this entire length; with here and there the houses of some small village clustered at their base or clinging to their steep flanks. The southward or southwestward facing slopes are covered with vineyards, the fruit of which goes largely to the making of the celebrated Rhine wines; the other colder slopes are clad in the green of dark forests. Clinging to the edge of the gorge or perched upon outlying pinnacles of rock, are the celebrated Castles of the Rhine, those strongholds of the ancient robber barons, from which they could make raids upon the commerce on the river below,—the only highway through this region,—or levy their scarcely more legitimate toll.

The Gorge division of the Rhine suggests the Hudson River of New York in its passage through the Highlands from Newburgh to Peekskill. The Rhine, however, possesses an historic interest

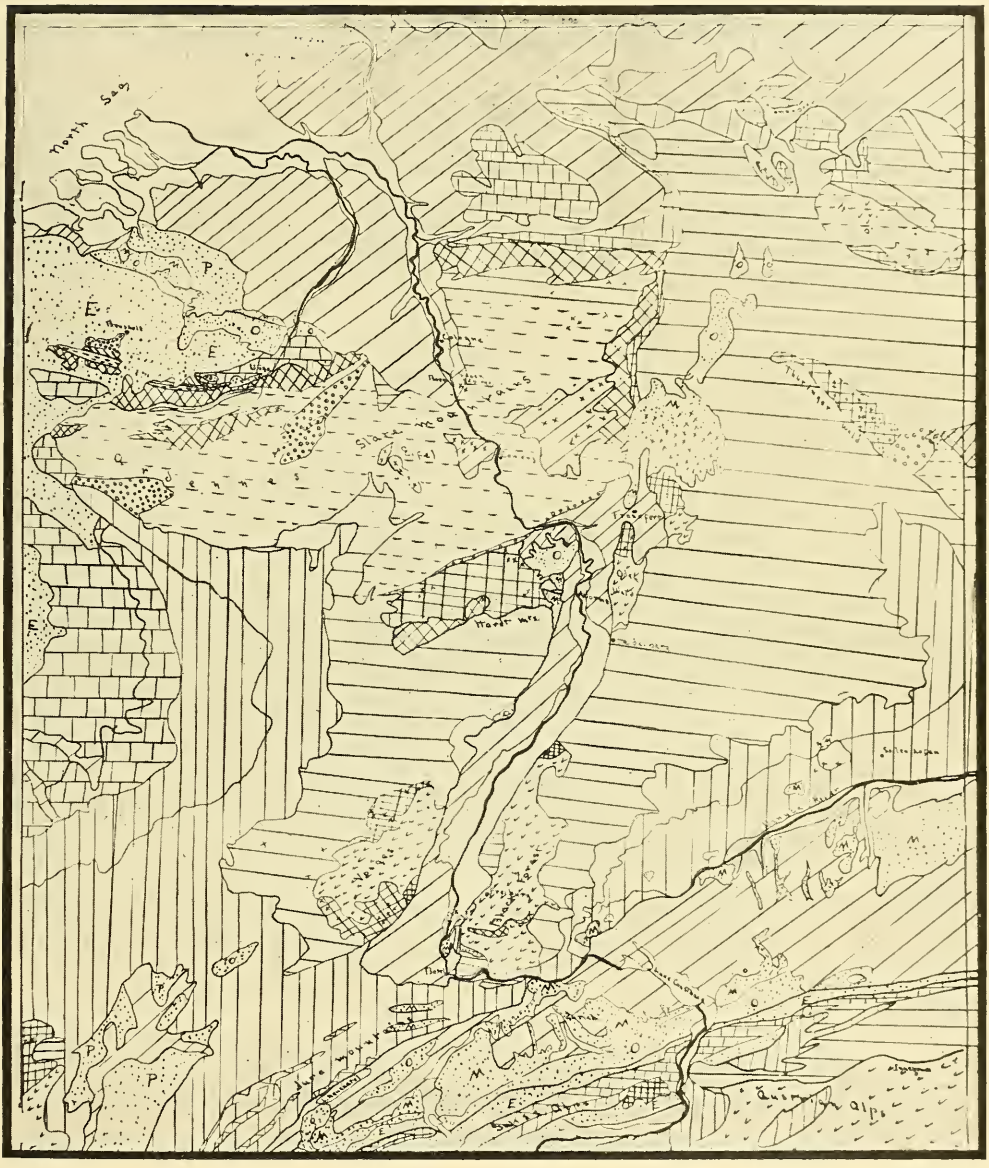

Fig. 1. Geologic Map of the Rhine Valley Region. The geological formations are indicated by the signs used in Fig. 3 (after Carte Geologique Internationale de l'Europe)

largely lacking in the latter, though the narrowness of its gorge and the low altitude of its bordering hills prevents the breadth of view which is one of the charms of the Hudson.

From Bonn to the North Sea, a distance of about 200 miles, the Rhine flows through a country which at first bears some low hills, but becomes later as flat as a slowly moving river, overflowing the surrounding country at the intervals of high water, could make it with its deposits of mud. In this, the fifth and last division of the Rhine, the river is sluggish

Fig. 2. Falls of the Rhine near Schaffhausen, Switzerland

and devoid of a solid rock bed, with a breadth of half a mile at its entrance into Holland. To the south lies the Great Belgian fault extending from near Liege westward. Along this line the land to the north has sunk, enabling the sea in earlier times to extend far inland over this region, but now again excluded by the mud which the Rhine is continually carrying with it.

During this long journey the Rhine descends over 6,000 feet. At Tschermut, some distance below its source, its height above sea level is 5,400 feet. Thence it descends rapidly to Chur (2,000 feet). At the end of the Swiss Valley division at Basel it has descended to 800 feet above sea level, at the end of the Graben division at Mainz to 200 feet, and at the end of the gorge at Bonn to 150 feet.

The embryonic Rhine grows rapidly by rivulet accretion and makes its way past its junction with the Hinter Rhine near Chur, on to its entrance into the broader, down-faulted valley at Vaduz. Throughout this portion of its course it is a rapid, foaming torrent, running at times through narrow, vertically sided canyons, and again, in regions of softer rocks, broadening into inhabitable valleys. The down-faulted valley in which the Rhine flows from Vaduz to the Lake of Constance extends north between high mountains, and averages in width some six miles. It is very rugged at its southern end, but becomes more level and hence more cultivated toward the north until, at the Lake of Constance, not only is the valley level, but the bordering mountains have become low and rounded. The Rhine now enters the Great Swiss Valley, expanding into the Lake of Constance, one of the four great lakes of Switzerland which lie in the valley.

In this large settling tank it loses all of the sand and mud torn from the Alpine rocks, which it still retained after its sluggish trip down through the valley to the south. The delta, resulting from the deposition of this sediment, is grad-

ually filling up the lake, and has already grown northward some fifteen miles, producing ideal farm land.

The shores of the lake are low, rounded hills, like the entire Swiss Valley

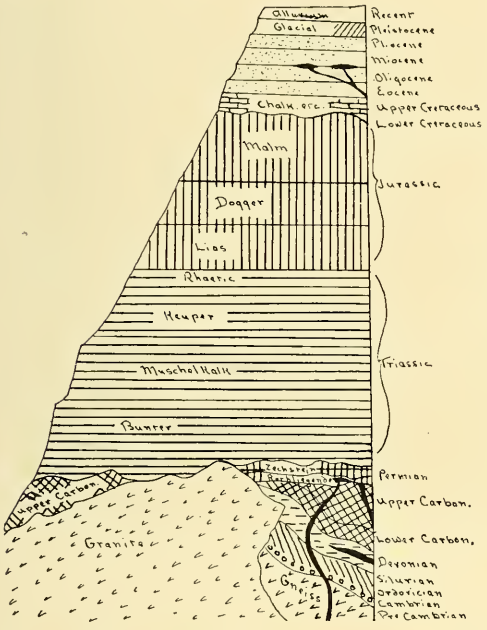

Fig. 3. The general succession of strata in the Rhine valley

and its eastward continuation to Vienna; so that the lines

> "Girt round with rugged mountains
> The fair Lake Constance lies"

can scarcely, even through the courtesy of poetic license, be applied to the region. At its exit from the lake the Rhine is very clear, but quickly picks up sand and mud as it hastens forward in its work of broadening and deepening its bed. Its shores remain comparatively low and rounded and its bottom consists of soft glacial sediment, except where, as at Schaffhausen, it leaps down over a bed of limestone (Fig. 2), and where, as at Laufenburg, it is cutting into the hard gneisses of a spur of the Black Forest. In this later part of its trip before reaching Basel, the hills are higher, formed of the Black Forest to the right and of the dying-out ranges of the Jura mountains to the left.

Though the Rhine river itself is a comparatively late development in geologic time, yet significant facts in its geologic career are found in the older history of the country over which it passes.

During the time of the Pre-Cambrian, the Cambrian, Ordovician, Silurian and Devonian, those regions which were under water received sediment, as Lake Constance or the seashores at present (Fig. 3). These sediments enclosed some of the shells or other remains of life then living, which are to us landmarks on the long road of evolution. A considerable amount of volcanic material was poured forth from the volcanoes of Devonian times. The lower and upper Carboniferous were periods of mountain building for all of central Europe. Some of the roots of these mountains, reélevated, form the present Black Forest, Vosges

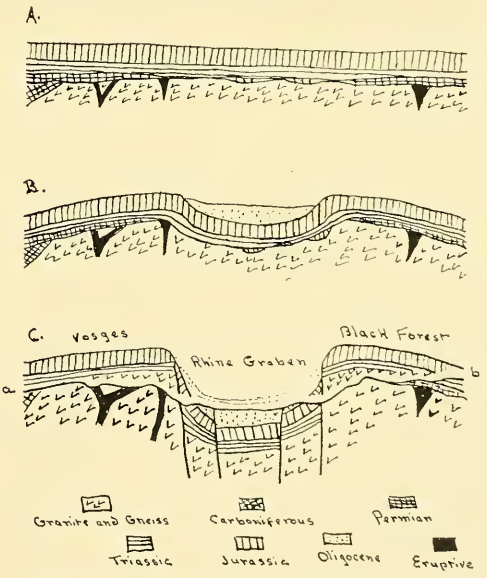

Fig. 4. The origin of the Rhine Graben. (Modified from Schmidt.) Vertical scale much exaggerated

A. At the end of the Jurassic.
B. At the end of the Oligocene.
C. At the end of the Miocene.
The line *a–b* represents the present surface of the land, the strata above having been removed by erosion.

Fig. 5. View of a portion of Heidelberg, from near the Castle. The Neckar River is in the foreground and the broad, flat Rhine Graben valley fades away in the background. The abrupt change from the elevated valley sides to the level Graben floor is well shown

and Slate Mountains. Accompanying this great upfolding of the earth's surface rocks, as is usually the case, was a widespread intrusion of igneous rocks such as granite. This granite is well exposed in the Odenwald, Vosges and Black Forest. These mountains were subjected to a long period of erosion, through the agency of wind and water. Some of the sediment thus gained was deposited upon the land by the rivers overflowing their banks on the way to the sea, and form what are now called the Permian and lowest Triassic (Bunter) rocks. Then the sea again invaded all of central Europe, remaining here until the end of Jurassic times, when it was withdrawn from most of what is now Europe, but returned again in the Upper Cretaceous. Each of these periods of sea transgression left sediment enclosing its own characteristic life remains.

During the Oligocene and Miocene the mountain-building forces focussed for the second time in central Europe, though mostly to the south of the ranges formed during the Carboniferous. They this time produced the present mountains surrounding the Mediterranean Sea, including the Alps, Juras, the Rhine Graben with its bordering hills and the Slate Mountains.

In the Lower Miocene period much volcanic activity occurred, producing the Eifel mountains and the Seven Mountains. During the Pleistocene, glaciers occupied most of the area under discussion, scouring loose rock from heights and depositing it in depressions, or at the ends of the glaciers, and damming drainage forming lakes and bogs.

The origin of the present form of the Graben division of the Rhine is shown in figure 4. The uppermost figure shows the Permian, Triassic, and Jurassic sediments resting horizontally upon the upturned and eroded gneisses and carboniferous strata and the intruded granites

Fig. 6. The Lorelei. A typical view of the narrow, steep-sided gorge of the Rhine and of the level plateau of the Slate Mountains, into which the river has cut

and other igneous rocks. About the close of the Oligocene (Fig. 4 B) this region was subjected to a horizontal compression which resulted in a low elongate dome with a north-south axis. As the central line of this dome was insufficiently supported there resulted a sagging in this area until finally this sinking block broke away from the rocks at the sides (Fig. 4 C and Fig. 5). The total depression of this block is about 3,000 feet.

The cities in or bordering the Rhine Graben have been celebrated since Roman times,—Freiburg, the doorway to the Black Forest, noted for its cathedral and university; Strassburg, in the middle of the perfectly flat Graben valley, with its large cathedral with the very complicated clock, its university and the many storks breeding upon the housetops, and Heidelberg with its most celebrated university and its thirteenth century castle. Worms and Mainz are both in the Graben valley, the former the city of the conference of *1521* under Emperor Charles V to discuss the heresy of Luther, and the capitol of the ancient Burgundian city credited with so conspicuous a part in the Niebelung adventures; for it was here that Hagen killed Siegfried for the Niebelung treasure and Kriemhild avenged her husband. Mainz is best known as the city of Gutenberg, the most credited inventor of movable type in printing.

Throughout the Graben valley the most used building stone is the brick red Bunter sandstone, since it is the most common bedded rock east and west of the Graben. Of it are built such conspicuous buildings as the Freiburg and Strassburg cathedrals and the Heidelberg Castle.

Beyond Mainz, after a short westward bending, the Rhine turning northward again enters at Bingen the narrow, meandering gorge through the Slate

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Mountains. This and the Alpine division are its principal zones of destructive action, just as the other three divisions, especially the Delta Plain, are its zones of construction. The meandering course of the gorge through these mountains is the Rhine's medal of honor for vast work accomplished,—that of wearing down, with the aid of wind and weather, and carrying away, particle by particle, those mountains raised during carboniferous time. It levelled them down to a plain, over which the river could wander almost at will, as it wanders now over its Delta plain. It at this time acquired these meanders which during Oligocene and later periods were impressed upon the slowly rising rocks beneath; the rise has been slow enough for the river to cut down its bed and not be deflected in another direction.

This downcutting work of the Rhine into the slowly rising country of the Slate Mountains has thus resulted in the formation of a narrow gorge (Fig. 6) in which the river is now working both to deepen and to widen its valley.

The level edge of the gorge as viewed from the bottom, or the still more impressive even sky-line as seen from the top of the gorge are the now raised floor of the plain upon which this portion of the Rhine acquired its meanders.

The ruined condition of the numerous castles along both sides of the gorge is mainly due to the activities of the generals of Louis XIV in 1689. Since that time several of the best preserved have been restored, but the vast majority still exist merely as crumbling ruins, ruins of intense interest, both historical and legendary.

At Neuwied the gorge suddenly widens, for it here enters the area of a small down-faulted block. This Neuwied basin has been partly filled with volcanic material, lava and ashes, but is still distinctly lower than its surrounding rim. To the west of this rise the low volcanic peaks of the Eifel Mountains, and a little farther down stream to the east rise the volcanic Seven Mountains, with Drachenfels the most conspicuous; both of these groups of hills are merely volcanic excrescences upon the Slate Mountains, for the plateau under each is the black, Devonian slate which gives name to the mountains.

Beyond Bonn the valley suddenly widens and the Delta plain division is reached. From there seaward the hills gradually become lower until floor-like Holland is reached, a country indebted to the Rhine for its rich soil, and, indeed, for its very existence. After traversing this level plain the Rhine through many mouths enters the North Sea.

THE LIGHT QUANTITY HYPOTHESIS

THE NEW IDEAS AS TO THE ATOMIC NATURE OF RADIANT ENERGY WHICH PROMISE SOLUTIONS OF MANY DIFFICULT PROBLEMS

BY D. F. COMSTOCK

Within the last few years the idea has been gaining importance that the light radiated from a luminous body is not emitted continuously, but in small indivisible "atoms of energy." This notion is totally unexpected from the standpoint of a decade ago, but evidence of one form or another is piling up so fast that it appears at present highly probable that in the end it may prove to represent the truth.

The idea was first put forward by a physicist of international fame, Professor Max Planck, of the University of Berlin. He was led to this conclusion through his study of the so-called laws of radiation.

In order to make a discussion of this hypothesis at all clear, it is necessary to speak of the phenomena of radiation in general. The simplest type of radiation which we know is that which a so-called "black body" gives off when heated. Perhaps the simplest black body we could take would be a tin cup covered with lamp black on the outside and filled with hot water. This body gives off heat rays in all directions which, as far as we know, differ in no way whatever from light rays except that they are on the average of a lower frequency, *i.e.*, they bear the same qualitative relation to light rays that the lowest note in the piano scale bears to the highest. These rays do not affect the eye because the retina is not so constructed that it can detect such relatively slow vibrations. The laws of propagation of the waves and their general characteristics are apparently, however, exactly the same as those of light rays.

Now if we suppose the cup filled with something besides water and to be slowly heated, hotter and hotter, we should notice two significant changes in this radiation which spreads out in all directions from the cup. In the first place, as it gets hotter, *more energy* will be radiated in a unit of time, and second, such energy as is radiated will have a higher average frequency than before. Making a sound analogy, we might say that this corresponds to the sounds given off being *louder* and of *higher pitch*. If this heating process goes on indefinitely the frequency will soon be high enough so that the retina of the eye will be affected by the rays and the object will be "red hot."

Now the exact way in which the radiation of a black body changes with increasing temperature, has been studied very carefully and several theoretical formulæ have been found which agree more or less closely with experimental results. Perhaps the most successful of these is the so-called formula of Wien which was derived from the fundamental conceptions of atomic theory. It is almost certainly true that the radiation from a hot body is caused by the chaotic to-and-fro motion of the atoms or molecules of which the substance is composed, and the general distribution of motion among the vibrating molecules or atoms is pretty well known at the present time. Wien obtained his formula by supposing that each molecule radiated energy in a way which depended only on its velocity at the instant in question.

Now although Wien's formula certainly contains some element of truth, it fails conspicuously at high temperatures. This failure has been realized for a number of years, but no suggestion was forthcoming in regard to *why* it failed.

This failure of Wien's formula is by no means an isolated fact of small importance. The ablest thinkers in theoretical

physics all over the world have considered at great length the theory of radiation, and although there has been more or less complete agreement among them, their results are not accurately in agreement with the results of experiment. Indeed a decade ago it was generally agreed that something was wrong with the fundamental notions underlying the theory.

In about 1905, however, Professor Planck came forward with an entirely new hypothesis. By one of the mysterious mutations which we call "inspirations of genius," he came to the conclusion that if we were to get a theory consistent with experiment, we must assume that the atoms do not radiate energy continuously, *but radiate only in small discrete quantities*,—"*atoms of energy*" *one might say*. From this point of view the oscillating part of an atom cannot possess *any* amount of energy, but only an amount which is a definite multiple of a fundamental unit of energy.

This is an extraordinary assumption and is in a sense a sudden jump in physical theory, but Planck showed that when one developed this hypothesis by well-known and rigid methods, an equation was obtained which differed slightly from Wien's formula and which was much more hopeful in its form. As a matter of fact, careful experiments have shown that as accurately as measurements have been carried out, Planck's formula is exact for all temperatures.

It is an interesting and suggestive fact that Wien's formula appears as a special case of Planck's when the temperature is not too high. In other words, Planck's formula contains apparently all the truth that is in Wien's and enough more to make it an exact representation of the fact. It is also an interesting sidelight on the rapidity with which apparently remote scientific hypotheses may react on the industrial world, that Planck's formula is already beginning to have an important effect on interpreting the results of the so-called optical pyrometers so extensively used in measuring the high temperatures of furnaces.

So extraordinary is the assumption of discrete quantities of energy that were it only applicable to the theory of radiation, the conception would not be as impressive as it has grown to be within the last few years, but curiously enough there is totally independent experimental evidence for it. Other results seem to indicate that light and similar wave motions propagate in the form of units of energy.

It is a well-known fact in physics that if a current is passed through any vacuum tube in which the vacuum is very high, a stream of electrons proceeds from the negative terminal in the tube and travels in straight lines. This stream of electrons constitutes what we know as the cathode rays. When these rays strike any obstacle, X-rays are emitted from the point struck just as sound would be emitted from a barn door struck by a shower of stones. These X-rays are considered to be of the wave-motion type of disturbance and not a stream of particles. The shower-of-stones-sound-analogy is therefore quite accurate, since sound is a wave motion. The analogy, however, fails of further application, for it is found that when these X-rays strike a metal they give rise to a stream of cathode rays (*i. e.*, a stream of electrons) which are called the secondary cathode rays and these cathode rays give rise to other X-rays. If the stone analogy were to be complete, the sound from the point struck by the stone would have to cause a stream of stones to come out of any substance which the sound struck.

Now the curious fact noticed about these electrons which spring out of a metal when it is struck by X-rays is that their maximum speed does not seem to depend on how intense the X-rays are, nor does it depend on the nature of the metal struck by them. If a piece of metal is taken farther away from the source of rays, so that the energy of the rays falling on it is less, it is found that fewer electrons come out of the metal in a unit time, but those that do come out have the same maximum velocity that they had when the metal was nearer.

Now a little thought will show that this result is totally inexplainable on the older ideas of radiant energy, for the

energy of the outcoming electrons is evidently derived from the energy of the striking X-rays, and as this energy spreads out indefinitely and gets weaker, it is to be expected that all effects produced by the energy would slowly dwindle away. This is not true, however; the emitted electrons come out with the same maximum speed as when far more energy struck them.

Now on the "light quantity hypothesis" the results are quite clear, for if the energy of the X-rays is really in the form of little particles of energy, then at greater distances from the source of the rays, the only difference is that the particles would be farther apart on the average. They are spread out more, but each has the same amount of energy and each is, therefore, capable of giving an impulse of the same strength to the electron in the metal which it happens to strike as it would have given had the metal been nearer; so that the experimental results totally inexplainable on the older idea of continuous energy radiation become readily explained when this "light quantity hypothesis" is applied.

Besides these two rather striking examples of the evidence for the light quantity hypothesis there are a number of others in which it is either definitely suggested by experiments or dimly foreshadowed. One set of results which seem to promise evidence in favor of the hypothesis are obtained in modern low temperature research. As is well known, the theoretical limit in diminishing temperature is the so-called "absolute zero." This is the temperature at which all atomic energy, or molecular energy of vibration would cease and is located at approximately 273 C. degrees below zero or 460 degrees below zero Fahrenheit. It is only very recently that temperatures at all approximating the absolute zero have been obtained, but now we have results on the electrical resistance of platinum wire measured at $1\frac{1}{2}$ degrees C. above the absolute zero. At this temperature, air and even hydrogen are solid.

Now at these very low temperatures there are certain unexpected anomalies in both electrical and heat phenomena. The so-called specific heat of substances, which from the older ideas should approach a certain definite constant as the temperature approaches the absolute zero, changes in a quite unexpected way as the temperature diminishes, for at these very low values it becomes so rapidly less as to approach zero instead of the constant finite value as above mentioned. It is very difficult to get any explanation of these low temperature anomalies on the older ideas of continuous energy distribution. On the energy quantity hypothesis, however, the results, while not yet worked out sufficiently to be called absolutely certain, are nevertheless very suggestive and promising.

Even in the domain of fluorescence an obscure question seems to be on the point of being cleared up by light quantity ideas, for it is well known in general, that fluorescent light is nearly always of lower frequency than the light which causes the fluorescence. This is in line with the new ideas, for although not yet mentioned in this paper, *the so-called atoms of energy are not all of the same size, but are larger in proportion to the frequency of light*, so that the size of the "atoms" corresponding to blue light is greater than the size corresponding to red light, and it is clear, therefore, that when a body fluoresces under stimulation from light of any color, it cannot give off larger light atoms (*i. e.*, bluer light) than it receives from the stimulating light; whereas it is perfectly conceivable that through some type of complex transformation, some of the energy might be left in a body and the energy quantities in the fluorescent light might be smaller (*i. e.*, the fluorescent light might be redder).

The light quantity hypothesis has not by any means been worked out so completely yet that its position and possibilities are well defined, but it seems at present full of promise and it is being used more and more by physicists throughout the world in explaining phenomena hitherto mysterious, both in the realm of radiation and in that of electricity.

THE PHYSIOLOGY OF EMOTION

PURPOSEFUL ELEMENTS IN THE BODILY CHANGES WHICH ATTEND EXCITEMENT—HOW MUSCULAR RE-ENFORCEMENT FOR EMERGENCIES IS SECURED

BY PERCY G. STILES

The physiologist, in contrast to the psychologist, looks at the features of human life objectively. Often he profits by adopting the other point of view, sometimes he finds that he has passed over to it when he did not mean to do so, but when he is strictly within his own province he regards a man as a mechanism and his brain as a collection of reflex arcs. Seen in this light the episodes of experience are recognized as adaptations, more or less successful, to changing external conditions. This is even the case with those emotional occasions which to our every-day thinking are essentially mental phenomena. The biological *raison d'être* of emotions—or of the general state of the body which attends them—has just been made clearer than ever before by the announcement of certain physiological discoveries. For these we are indebted to the ingenuity and insight of Doctor Walter B. Cannon.

While we commonly speak of the bodily conditions which are observed in connection with anger or terror as resulting from the mental state we must consider that we have no right to assume any such relation. All that we can safely say is that one is the accompaniment of the other. The James-Lange theory of emotions makes the feeling the outcome of the characteristic muscular tension; one feels anger because the hands are clenched and the forehead creased. Happily the physiologist need not pass upon the question as to whether the feeling or the bodily action is primary. His concern is to find out whether the welfare of the organism is served by the process.

The more obvious concomitants of strong emotion include the familiar muscular adjustments which produce suggestive postures and facial expressions, the changes in the breathing, and the disturbances of the heart's beating. Equally evident are the flushing and paling of the skin which show that the vaso-motor system is involved. That the glands share in the awakening is plain from frequent instances of sweating and salivation as well as from the shedding of tears. Scientific analysis has made it apparent that some of the manifestations of emotion are inhibitions; that is to say, that there is not an indiscriminate stirring up of all the tissues to increased activity but that there are restraints imposed upon some organs. So we may have momentary standstill of the heart, brief arrest of breathing, suppression of secretion instead of stimulation.

Doctor Cannon himself in earlier contributions has shown that the movements of the stomach of the cat may be interrupted when the animal is agitated. Pawlow, the Russian experimenter, has proved just as decisively that the secretion of the gastric glands may be withheld when circumstances interfere with the enjoyment of a meal. Clinical experience teaches that the observations made upon the lower animals are valid for human beings. It has been natural to emphasize the potency for mischief which is incidental to such inhibitions. We cannot yet say of every manifestation of emotion that it is surely an adjustment for the advantage of the individual in the existing emergency. But we can see a purposeful character in some elements of the process that formerly seemed meaningless.

Under primitive conditions of life the

feeling of fear coincides with circumstances which make flight the rational course of action. Rage is felt when the best move for the animal—or for the savage man—is an attack on a foe. Now whether to flee or to give battle the need of the moment is for the most complete command of muscular resources. Two features of the emotional reaction have been shown by Doctor Cannon to favor precisely this attainment. One of these is an increase of sugar in the blood. The other is the extra production of adrenalin, the active substance contributed to the circulation by the small organs known as the adrenal bodies.

A rise of sugar above the low but usually constant percentage in the blood is demonstrable after a terrifying experience both by direct measurements and by the occurrence of sugar in the urine, the sign of an overflow through the kidneys. The source of the sugar is doubtless the starch-like reserve called glycogen which is normally held in the cells of the liver and muscles in readiness at any time to undergo conversion to sugar and to enter the blood-stream. Why should the transformation of glycogen to sugar occur at an emotional crisis? Because, we believe, sugar is the most available fuel which can be utilized to supply the energy needed for muscular contraction.

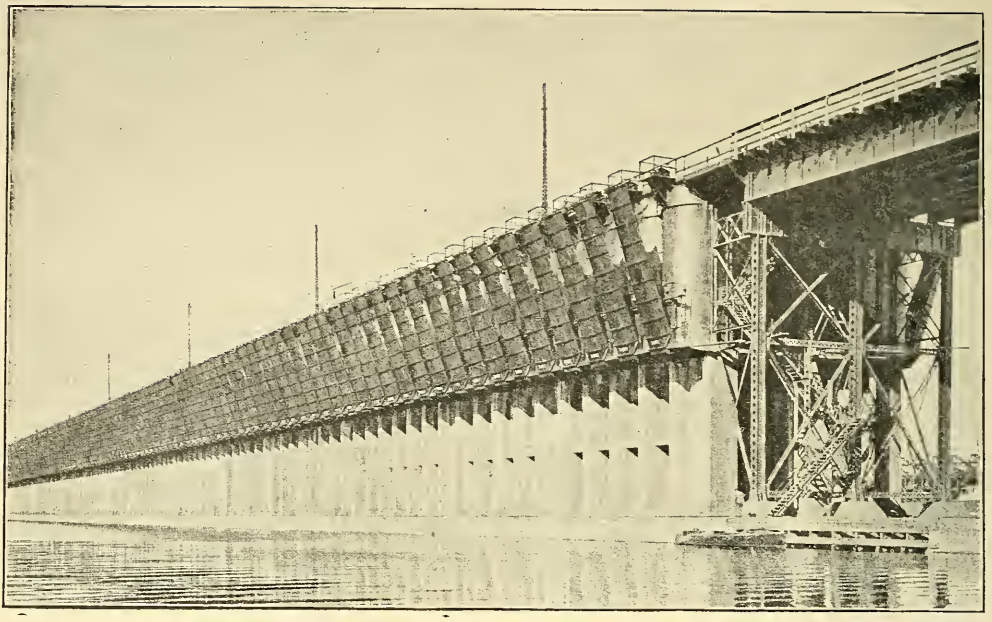
As to the value of the additional adrenalin turned loose at such a time a clear explanation is at hand. Doctor Cannon finds that it is an agent capable of postponing fatigue. If it is caused to circulate by artificial means through muscles which are flagging from continued work the renewing effect is very marked. There can be no question that when the adrenal bodies of an animal are played upon by the nervous system in moments of intense excitement the secretion which they discharge to the blood has the same favorable influence. Exhaustion is delayed and for a while there is an exhibition of unlooked-for power. This would seem to be nothing more or less than the "strength of desperation" often referred to and now seen to have a physiological basis.

Many of the physical accompaniments of emotion can thus be held to be of service. The cardiac and vaso-motor changes are probably such as insure readiness for action. The dealing out of sugar to the blood provides abundantly for the demands about to be made on the muscles. Even the inhibition of the alimentary canal is, perhaps, an instance of economy in one quarter to sustain liberality in another. Finally the issuing of adrenalin to the tissues reminds one of the theory on which grog used to be served to sailors before a sea-fight. That is to say, the purpose is to get the most possible out of the existing equipment. It will be observed that these reactions fit aboriginal rather than civilized environments. The emergencies which arouse us are usually to be met with intelligent and temperate action rather than with physical conflict. It will also be noted that the profound after-effect of even a brief emotional tempest is just what we should expect from a process so far-reaching and inclusive in its sweep.

VEGETABLES AND TYPHOID FEVER

Recent experiments have demonstrated that fruits and vegetables may act as vehicles of typhoid fever to a rather surprising degree. Soil upon which lettuce and radishes were growing was inoculated with fecal material containing typhoid bacilli. Some of the plants were then kept indoors, being sprinkled from time to time to simulate rain, while others were allowed to grow in the open exposed to the elements. Examinations of the leaves and stems of these plants for typhoid bacilli were still successful after twenty-five days in the plants kept indoors, after thirty-one days in those kept out of doors part of the day, and after ten days in those exposed during the entire day. Bearing in mind the ordinary country methods of sewage disposal it is easy to understand how typhoid fever on a farm may be transmitted to city-dwellers by garden truck.

F. S., JR.



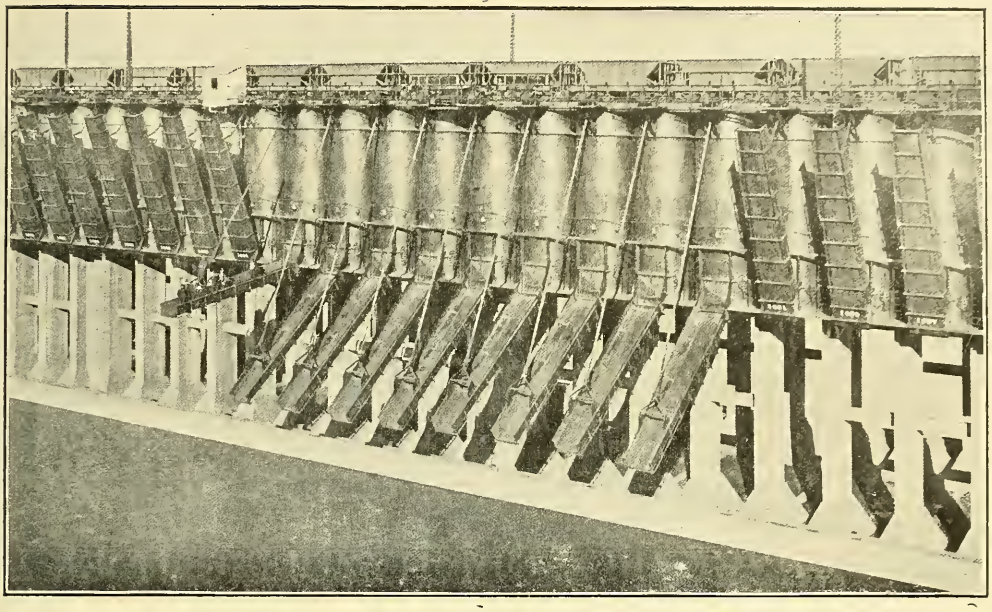
General View of the Great Northern Ore Dock at Allouez, Wis.
Courtesy *Engineering Record*

A REMARKABLE ORE-HANDLING DOCK

In order to care for its very heavy tonnage of ore from points on the Mesabi Range, the Great Northern Railroad has built the large ore dock at Allouez, Wis., on Lake Superior, which is illustrated on this page. This dock is the largest of its kind on the Great Lakes, being 1900 feet long, 71 feet wide over all, and having its top 75 feet above the mean water level. There are 151 pockets, or bins, for ore on each side, built to the standard spacing of 12 feet to fit the hatches of the ore-carrying vessels on the Lakes. Each of these bins has a capacity of 325 tons, and is designed to hold seven 46-ton carloads of ore, although as it is usually operated only six carloads are dumped in one pocket. The total capacity of the dock is 98,180 tons or 2,115 carloads, or 42 trains of 50 cars each. The dock is built for the purpose of handling ore, and not for storage, and has proved itself one of the most efficient loading docks on the lakes.

In operation a train is run upon one of the six tracks on top of the dock and the hopper-bottom ore cars are dumped into openings in the tops of the pockets. These openings are so spaced that a whole train may be dumped while standing in one place. The six tracks are used to distribute the ore evenly through the pockets and obviate trimming. The flow of the pockets slopes at an angle of 47 1-2 degrees with the horizontal in order to insure the free movement of the ore in flowing out to the vessels. As will be seen from the illustrations, the ends of the pockets are made semi-circular. This was done to prevent "arching" or clogging of the ore in the pockets, which would interfere with its flow. It has been found that these pockets empty practically completely, only about half a ton of ore remaining in them.

Soon after the completion of the dock 9,500 tons of ore (200 carloads) were loaded into a single vessel in 25 minutes.



Side View of the Dock with Ore Cars on the Structure. Courtesy *Engineering Record*

and at another time 8 vessels with an aggregate tonnage of 62,000 tons were loaded in six hours. Six of the largest ore boats can be loaded simultaneously. The spouts for loading the ore into vessels are seen in the second illustration. Some idea of their size may be obtained from the eight or nine men shown standing in one of the spouts. Each spout is 34 1-2 feet long, 5 1-2 feet wide at its upper end, and 4 feet wide at its lower end, the idea of the taper being to increase the friction of the ore against the sides in order to prevent its being shot into the vessels too violently. The spouts are raised by electric hoists and are not counterweighted. One 25-horse-power alternating current motor is provided for every ten spouts. Each spout may be operated independently, or several may be operated at once by the one motor. The connections of the shafting are such that in case a motor breaks down, the spouts worked by it may be handled by one of the adjacent motors. The spouts are lowered under control of the motor, and cannot drop suddenly.

The sliding doors of the bins are raised by hand winches, and once opened cannot be closed until the bin is empty.

As will be seen, massive concrete columns instead of the usual steel ones, are used to support the pockets. The columns rest on timber cribs, which are supported on piles. Transverse strength is secured by the partition walls of steel between the pockets. The approach is a long timber trestle, with 300 feet of steel trestle next to the dock. Expansion of the structure is taken care of by expansion joints at 120 feet intervals.

The dock is lighted by flaming arc lamps supported on steel posts 35 feet high and 192 feet apart. The use of the flaming arc lamps materially reduced the number of lamps required. L. E. M.

NEW MEMBERS OF THE SOCIETY

At the 678th meeting of the Society of Arts held February 20, the following applicants for membership were elected:

James T. Connor, 23 Englewood St., Dorchester, Mass.

P J. Doherty, 95 Milk St., Boston, Wass.

Roland B. Pendergast, 48 Beacon St., Boston, Mass.

Sarah E. Radway, 67 Beacon St., Boston, Mass.

POISONING BY ILLUMINATING GAS

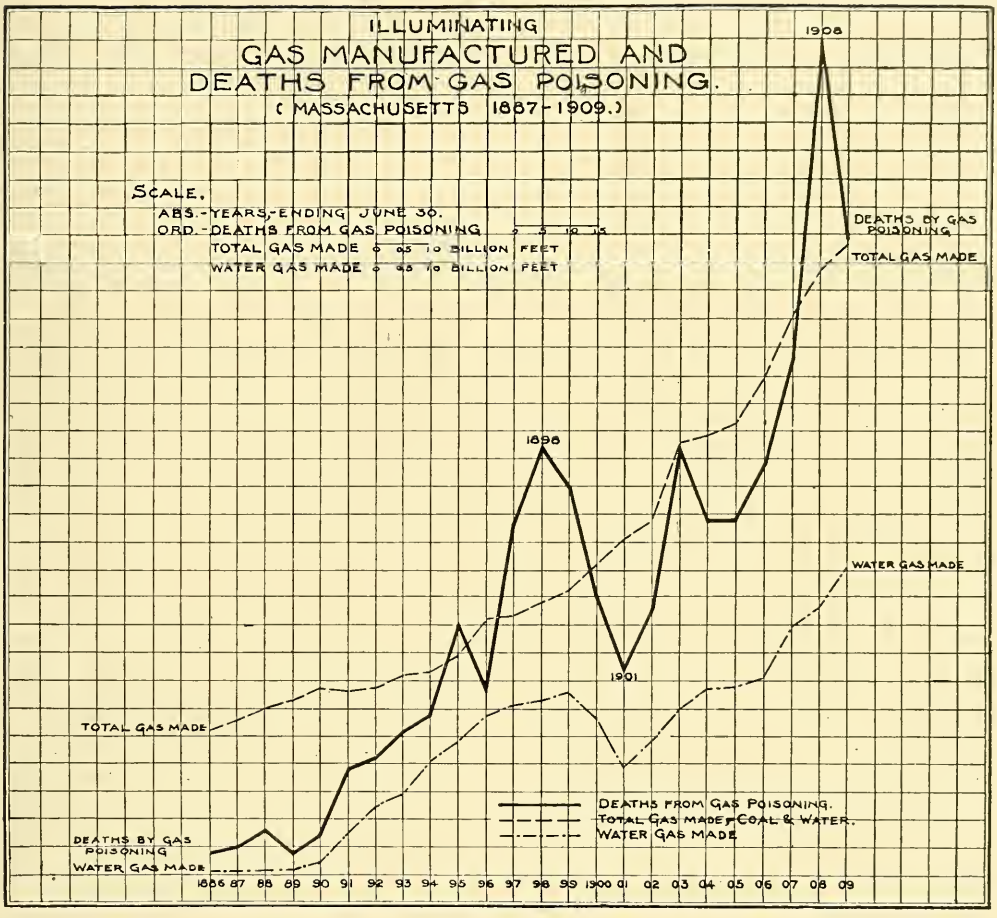
While the general public realizes that asphyxiation and death from illuminating gas poisoning are not uncommon, few comprehend the actual extent of the damage done and the preventability of the loss. Twenty-five or thirty years ago accidents of this kind were extremely rare, and deaths were almost unheard of; now they have become everyday events and the mortality rivals that from some of the more serious contagious diseases. In Massachusetts alone, in the twenty-year period ending with the year 1909 over 1200 persons died from gas poisoning. In New York City, according to the daily papers, there were reported to the coroner in the first six weeks of the present year seventy-five fatalities. The death-rate from this cause in Massachusetts has in some years exceeded that sometimes occurring from such widely feared and strenuously combatted diseases as measles and scarlet fever, and it is now higher than the rate for typhoid fever in many European and in some of the better American cities. The fact is that illuminating gas has come to be a serious, an increasingly serious, cause of death, and a point has been reached where it behooves health authorities and others interested in the subject to consider what steps can be taken to curtail this shocking mortality.

The deaths occur in a variety of ways. Sometimes they are cases of suicide,—a gas tube often being inserted in the mouth by the victim. Again it may be an undoubted accident, as when a family is asphyxiated even when there is no gas piping in the house, the gas entering through the cellar from a broken street main. Between these extremes there are cases of a doubtful character, in which it is practically impossible to decide whether the victim accidentally failed to completely close a gas cock or whether intent entered into the act. In the more than 1200 deaths investigated in Massachusetts the ratio between accidents and suicides was just about half and half.

An interesting point in connection with these deaths is their seasonal distribution, being relatively infrequent in the summer and most numerous in the cold winter months when the houses are more tightly closed, the days are shorter, and more gas is consequently used.

Demonstration of the preventability of gas poisoning has been one result of investigation of the subject. It would appear that practically the controlling factor is the nature of the gas distributed. In those localities where only the old-fashioned "coal-gas" is furnished, fatal cases are extremely rare; in places where the newer "water-gas" alone is made, deaths are frequent. The sudden rise of fatal gas poisoning about twenty-five years ago coincides with the discovery and introduction of "water-gas," and subsequent variations in the number of fatalities have, in Massachusetts at least, followed closely on corresponding variations in the production of this gas. An example in point is the experience of the year 1901. At that time the installation of the New England Gas & Coke Co.'s large plant at Everett resulted in a very considerable increase in the amount of "coal-gas" manufactured in the state, with a consequent decrease in the production of "water-gas." Despite the fact that in 1901 suicides in general ran high the result was at once manifest in a sharp drop in deaths from gas poisoning. These facts, as well as the general rise and fluctuation of the deaths, are brought out in the chart.

The controlling influence of "water-gas" is easily understood when its chemical composition is compared with that of "coal-gas." Whereas the former contains about 30 per cent. of carbon monoxide, well recognized as a highly poisonous gas, the latter contains only about 6 per cent. It has been shown by experiment that with gas escaping from a common fixture in an ordinary room this difference in composition makes that between comparative safety in the case of "coal-gas" and comparative


ILLUMINATING
GAS MANUFACTURED AND
DEATHS FROM GAS POISONING.
(MASSACHUSETTS 1887-1909.)
SCALE.
ABS.-YEARS,-ENDING JUNE 30.
ORD.-DEATHS FROM GAS POISONING
TOTAL GAS MADE 0 05 10 BILLION FEET
WATER GAS MADE 0 05 10 BILLION FEET
1908
DEATHS BY GAS POISONING
TOTAL GAS MADE
1898
1901
WATER GAS MADE
TOTAL GAS MADE
DEATHS FROM GAS POISONING.
TOTAL GAS MADE, COAL & WATER.
WATER GAS MADE
DEATHS BY GAS POISONING
WATER GAS MADE
1886 87 88 89 90 91 92 93 94 95 96 97 98 99 1900 01 02 03 04 05 06 07 08 09

danger in the case of "water-gas." Evidently if the production of "water-gas" could be curtailed, or the allowable amount of carbon monoxide limited by law, as was the case prior to 1890, we would have a solution of the problem.

Just how relief will be obtained is not clear. To the simple remedy of forbidding the manufacture of "water-gas" there is the obvious objection that such a course would be unfair to the existing "water-gas" companies. On the other hand, the building of new plants might be restricted. It has been suggested that "water-gas" might be "denaturized" by the addition of some extremely irritating substance, so that the escape of the gas could not fail to be detected and sleeping persons be roused. This suggestion will become more helpful when some one has some satisfactory and really effective substance to suggest. Safety fixtures should also aid, but although some devices show promise, nothing of this sort really adequate has as yet been evolved. When all is said and done, unavoidable accidents are bound to occur and it seems inevitable that some reasonable limit must be set on the percentage of carbon monoxide. Gas poisoning which has already grown in civilized communities to startling proportions, is now steadily increasing, and yet it is almost wholly preventable. Is it not time, then, that the State should take up the matter and establish measures to prevent this great loss of human life?

The complete paper, giving details and illustrated by other charts can be found in the *Journal of Infectious Diseases*, Vol. IX, No. 3, 1911.

F. S., JR.

ADULTERATION IN MARASCHINO CHERRIES

One of the most interesting of the disclosures with regard to the adulteration of food products has been recently made through the investigation of the Maraschino cherry. It will be news to most people to hear that there are very few genuine Maraschino cherries on the American market today. This fact is due to the almost prohibitive cost in this country of the genuine Maraschino cherry which must be imported from Dalmatia and due also in a considerable degree to the demand of the American people for a pleasing appearance in their food: —a requirement which is not met by the real Maraschino cherry, a small, dark, and shrivelled object.

The article that generally passes for the Maraschino cherry has been evolved through several stages of experimentation. The original cherry was grown in Dalmatia as before stated, and this has not been cultivated elsewhere on a commercial scale. It derived its name from a place called Marasca, and was first used to make a liqueur. In time the Maraschino liqueur was put to purposes of flavoring, and finally the cherry itself was used to ornament drinks, ices, grape fruit and so on. Dissatisfaction with the appearance of the cherry led to an attempt to dye it, and the light green Maraschino cherry resulted. Then some one tried a red dye, and the color which we chiefly associate with the Maraschino cherry came into general use.

The under size of the genuine article, its high cost, and the difficulty of satisfying the increasing demand for Maraschino cherries, with college ices on the list of drinks at every soda fountain, naturally led to further experimentation to see if some satisfactory imitation could not be made.

From France a cherry large and attractive to the eye, known as the Bigarreaux cherry, is now exported to America to be used in the construction of Maraschino products. In most instances cherries are shipped packed in a solution of common salt and sulphurous acid that bleaches them during transportation. This sulphurous acid is removed on arrival by washing with water. The cherry is then dyed and after that artificially flavored with benzaldehyde or other substances.

At present it is required by law that none but the genuine cherry preserved in the original liqueur may be sold under the label "Maraschino Cherries." All others must be marked "Imitation Maraschino Cherries" although they may contain a large percentage of Maraschino liqueur.

Some danger exists in the consumption of the artificial varieties on the market today because sufficient care is not always exercised in washing out the acids used for and produced by the bleaching process. If properly prepared, however, the imitation cherry may be quite as healthful as the natural product.

E. B. S.

RINGWORM

The name of this well known skin disease is a misnomer, the trouble being caused not by a worm but by a little plant —one of the mould fungi. The disease is familiar to the layman as a small red ring an inch or so in diameter enclosing a clearer area, and occurring on the surface of the skin, frequently on the face and hands. The rings are formed by a gradual outgrowth from the center, the clear area being tissue which has recovered from the disease. The fungus parasite attacks principally the hairs, working down into the roots and spreading through the top layer of the skin. A number of varieties of ringworm exist, attacking both man and the lower animals, and some are communicable from the one to the other.

Another related fungus of a higher order is responsible for the so-called "fairy-rings" of toadstools observed in forests. Here again the fungus spreads from a center, branching out underneath the surface of the soil, and sending up its fruit bodies—the toadstools—in ever widening circles. The analogy between ringworm and fairy-rings applies both as to causal agent and manner of growth.

F. S., JR.

SCIENCE CONSPECTUS

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THE MODERN AEROPLANE

THE PLAIN FACTS ABOUT AVIATION AND AEROPLANES TOLD BY A LICENSED AVIATOR AND EXPERT PERFORMER, WHO IS ALSO A SKILLED ENGINEER

Smithsonian Institution
3978
JUL 22 1915
Astrophysical Observatory

BY EARLE L. OVINGTON

I PREFER to divide the development of the aeroplane into two periods; first period being before man made a sustained flight, and second period after sustained human flight was accomplished.

As far as history tells us, the opening of the theoretical period may be considered as starting with the glide of Oliver of Malmesburg, who, in the eleventh century, jumped from a tower in a glider and managed to glide 370 feet before breaking his leg.

In spite of the fact that it is generally considered that to the Wright brothers belongs the honor of the first flight in a heavier-than-air, power-driven machine, this is not the case. To be sure at Kitty Hawk, North Carolina, on December 15, 1903, the Wright brothers made a flight of 852 feet. As far back as October 9, 1890, however, Clement Ader, a Frenchman, flew 174 feet. As both of these flights came to an end on account of deficient lateral stability of the machine I do not consider them practical flights. The first real aeroplane flight of any consequence was that of the Wright brothers at Dayton, Ohio, on September 26, 1905, when they flew for eighteen minutes and covered a distance of eleven miles. It must, indeed, be a practical aeroplane which can accomplish such a feat. I consider, therefore, that the practical period of aviation commences with this latter flight of the Wright brothers.

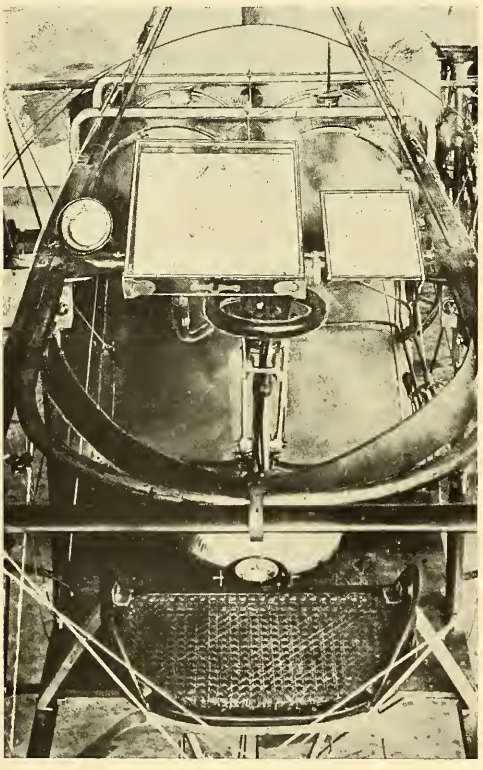
It is a peculiar fact, but nevertheless true, that during the first or theoretical period much of the best work along research lines was accomplished. Evidently after man had learned to raise himself from the ground by means of a power-driven machine, he was so busy playing with the new toy that he could not devote the painstaking care necessary for scientific research.

Now that the aeroplane has reached a relatively high state of development I believe that we should again revert to the scientific man. In other words, I believe that the future of the aeroplane hereafter rests largely with the scientist as compared with the man operating by rule of thumb. To the laboratory we must look for our greatest addition hereafter to the scientific knowledge of aeronautics.

The essential features of the modern aeroplane, whether it is a monoplane or a biplane, are as follows: main supporting planes, fuselage or body, landing chassis,

motive power, propeller or propellers, and means for horizontal and vertical steering, as well as for maintaining longitudinal and lateral stability.

There is no difficulty in steering an aeroplane to the right or to the left, nor is there any difficulty in maintaining its stability in a fore and aft direction. The longitudinal stability of the modern aeroplane is well nigh perfect. Five times over the city of Boston at a height of 3,000 feet I took my hands from my



A Complete Equipment.—Cockpit of the author's 70 H. P. Gnome driven Blériot Monoplane

longitudinal control. The machine did not pitch forward violently or have a tendency to settle backward, but assumed a natural gliding angle. The aeroplane of today, if properly designed, is longitudinally all that could be desired.

The problem that is awaiting solution and the problem on which the whole future of the aeroplane depends, is that of maintaining what is called lateral stability. In other words, keeping the machine in more or less of a horizontal plane.

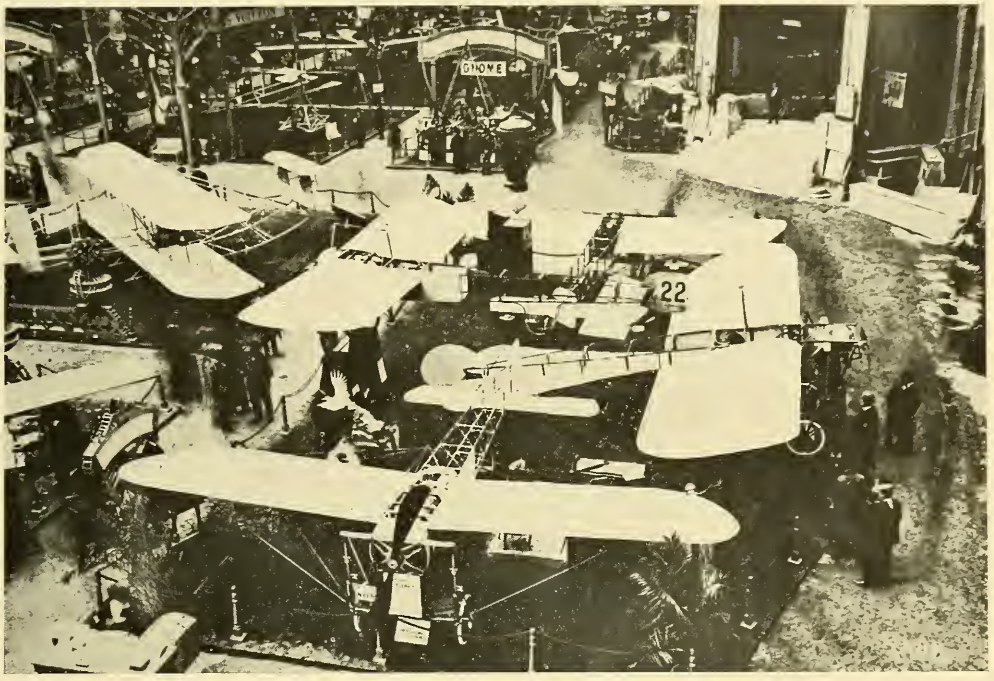
Any aviator will agree with me when I say that the operator at the control of a flying machine is in very much the same position as the tightrope walker. He is balancing at all times upon the invisible air currents just like the tightrope walker is balancing upon his narrow support. It is the continual strain of this lateral balancing which makes aeroplane flying today as difficult as it is. It is this continual fighting with the tendency of the machine to capsize, which makes the aviator a nervous wreck in a few months unless he is very careful. Some men stand this mental strain better than others; the ability to resist the action seems to be constitutional. It affects them all, however, to a greater or less extent.

For the benefit of those who may have some ideas on this subject of lateral stability, or who may wish to study it, I should like to say a few words more on the subject.

There are three methods of maintaining a flying machine in a normal position viewed from a lateral stability standpoint. First: the control of the machine by means of the aviator. Second: the control of the machine by means of automatic devices, such as a pendulum or a gyroscope. Third: building the aeroplane surfaces in such a manner that they are inherently stable.

The first method is the method employed at the present day in practically all modern aeroplanes. In this case the life of the aviator depends upon his ability to maintain his lateral stability.

The second method is one almost always striven for by the novice and the man who knows little about aeronautics. The aviator who has actually flown knows that he would rather risk his life to his own brain than to some automatic device. Assuming that a perfect automatic device could be obtained, there would come a time when it would cease to operate, and then death might result, or at least a serious accident.



Paris Aviation Exhibition in the Grand Palais—Financially more successful than any of the automobile shows held there

I believe that the future of the aeroplane will evolve a machine having *inherent* lateral stability, which is the third method of the three above mentioned, and until this time comes, the aeroplane will not be the universally used vehicle. I am sure it will be sooner or later.

Many people have asked me why birds are able to soar as they do without the expenditure of energy on their own part. This has ever been an interesting problem to the students of aerodynamic flight, and in spite of the fact that there is considerable mystery attached to the phenomenon among laymen, it is well understood among those versed in the art.

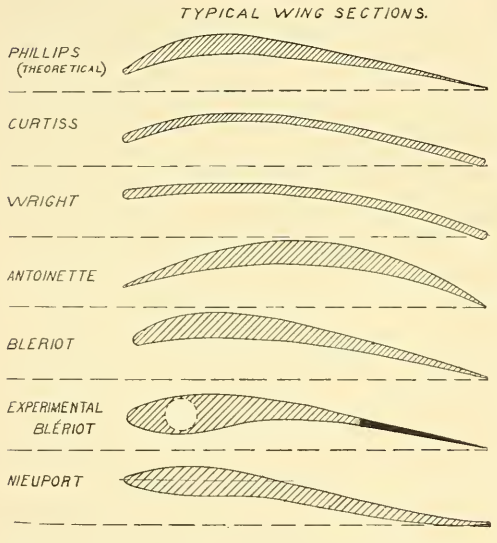
Broadly speaking there are two classes of birds; the flapping bird and the soaring bird. The wings of the former are short and thick, that is, they have a low aspect ratio, the aspect ratio being the ratio of the length to the breadth. Their wing area, too, is small per unit weight. Vigorous flapping is necessary for flight, and enormous energy is expended compared with that used by the soaring bird.

In the case of the soaring bird, of which the condor and turkey buzzard are the best examples, the wings are long and narrow, that is, their aspect ratio is high. The wing area is comparatively great when the weight is considered. Flapping is not only unnecessary, but is often absent for hours. Where, then, do these birds get their energy?

It is easy to understand that if a bird were to jump off a prominence such as a high hill or a church steeple, he could glide gradually to the ground. Now I think it will be equally evident that if after the bird had found himself launched in the air, he discovered that the air was rising rapidly, he could actually remain stationary with regard to the earth, although he would be falling with respect to the surrounding air which was sustaining him. This is what happens in most cases of flights by soaring birds.

Although there may be no appreciable wind at a given moment, if we could see the movement of the air, we would find that it was rising over some portions of the ground and descending in the other neighboring portions. In other words, the air may be warmer in certain places and rise, while being colder in others, it descends. The birds have a faculty of utilizing the rising currents of air, and often soar for hours in circles utilizing the upward trend of such air currents. Or perhaps they may use the upwardly deflected current from some hill or other prominence.

This, too, explains why sea gulls can



follow an ocean liner without flapping. The air is rising from the stern of the boat because it is heated, and the gulls soar in this rising current of hot air. It is interesting to note in this connection, that the energy of the coal burned under the furnaces of the boat supplies not only the necessary energy to propel the giant ocean greyhound through the water, but furnishes the power which enables the little winged followers to glide forward through the air without the effort of propulsion. The gulls, when soaring, are literally abstracting the energy they require from the air itself.

There are cases where a bird can soar in horizontally moving currents. For instance, suppose the bird is gliding forward at a certain speed against the wind, but in a slightly downward direction. Now assume that the wind velocity is increased. It is evident that the bird will be able to rise, abstracting some of the energy from the pulsation of the air sustaining him. But this is not the usual means by which birds soar—it is only utilized under certain conditions.

I have often been asked the question whether man will ever be able to soar as the birds do. It may be that in the distant future we may develop in us a sense which will enable us to "feel" the invisible currents of rising air, but I very much doubt it. Neither do I see as it would be of great benefit, as unquestionably all birds have to flap if they wish to go definitely from one point to another, and the conditions are not such that they can soar. I do believe, however, that the time will come when five or, at the most, ten-horsepower, will be all that is required to carry a man through the air in a flying machine. Under such circumstances it would make little difference whether soaring flight were possible or not, that is, soaring flight without an engine.

A question which undoubtedly has been asked me more than any other is, "How does it feel to go up in an aeroplane?" People seem to think that every time I get into the machine and go off the ground I am terribly frightened, and only manage to control myself with the greatest effort. And they are under the impression that if they themselves went up, they would probably be in a panic of fear.

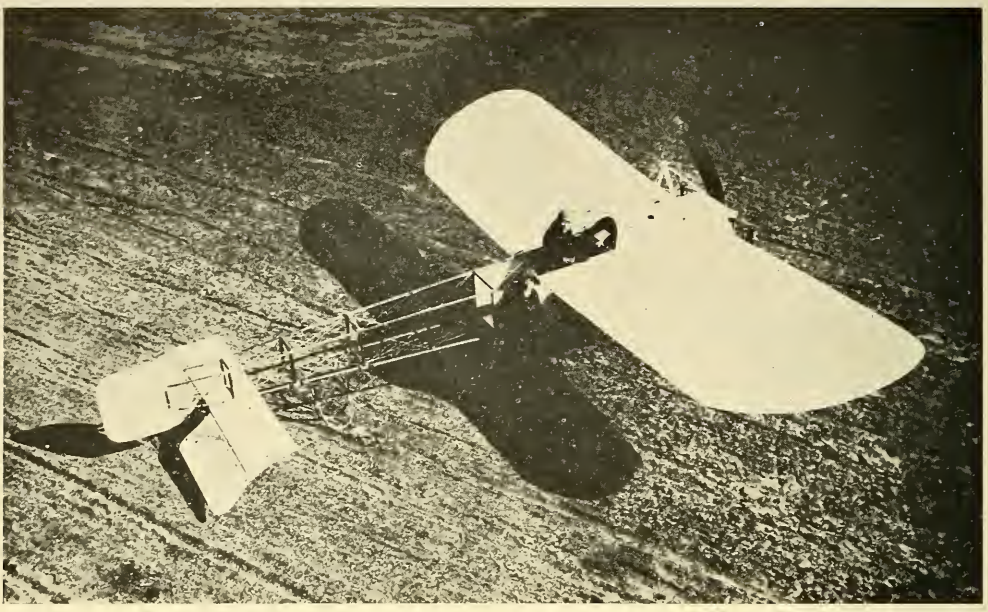
Nothing is further from the case. I have seen a great many ladies go up as passengers—timid society women who would scream with terror at the sight of a mouse. At first, of course, while they were taking their seat in the aeroplane and preparing for the flight, they would be nervous. I presume they felt very much like a criminal about to be electrocuted. The dread of anticipation, however, is the greatest unpleasantness of the whole proceeding. A passenger is no sooner in the air than a false feeling of safety is experienced. I say it is false,

The Students' "Dummy" at the Antoinette School in France. This permits the student to practice before actually attempting flight

because aeroplaning of the present day is distinctly a dangerous pastime. As one looks out, however, over the immense planes of the machine, and hears the positive and reassuring roar of the motor, it seems impossible to grasp that this man-made bird could fall.

In my own case I made my first flight with Maurice Farman at Buc in France. The day was calm, and after a momentary uneasiness, I settled down to really enjoy my first flight. Instead of the aeroplane leaving the ground, it seemed to me that the ground was leaving the aeroplane, and that we were suspended in the air, as if supported by a balloon instead of by the reaction of the air on the wings of the machine. As we climbed higher the earth appeared to be falling further and further away from me, and when we had reached a height of 500 feet, all nervousness had disappeared. So much so that I was talking, in rather a loud voice to be sure, to my pilot. What was my surprise when Mr. Farman indicated that I was to take the controls of the machine. I did so with some trepidation, but managed without difficulty to steer the aeroplane and maintain its stability. Mr. Farman would not have taken these chances had he not known that I was thoroughly acquainted with the theory of the subject. He realized how easy it was to fly on a calm day in a big biplane, and so had no hesitance in handing me the controls of the machine as soon as we got far enough away from the ground to prevent a sudden swoop causing an accident. Of course he was ready at a moment's notice to check me, if I made a false move, but this was not necessary. Indeed, I was surprised at the ease with which an aeroplane could be manipulated.

Don't gain from this that flying is always so easy. In the first place I was in a big biplane, and in the second place the air was comparatively calm. Flying



The author's 70 H. P. Gnome Driven Blériot Monoplane

in a wind is a different proposition, as I have learned since. Flying an aeroplane on a calm day, and flying one in a high wind, is the difference between rowing in a flat-bottomed skow on a mill pond, and handling a sailing canoe in a gusty gale.

I have the honor of having made the first aeroplane flight over the city of Boston. I started from the Waltham aerodrome, and after I had reached the height of three or four thousand feet, I headed in the direction of Boston, and was soon sailing over the Back Bay district. Far below me I could see the little ant-like people as they ran backwards and forwards through the streets. The bridges over the Charles River were black with mites of humanity. The river itself was strewn with pleasure craft filled with those who had come to see me fly, since it had been anounced the day before in the newspapers that I would make the attempt.

I was told to steer for the State House dome, and would have no difficulty in finding it because it was gilded. I looked around and couldn't see anything that looked like gold, although I flatter myself that I can detect the presence of the yellow metal about as far as the next fellow. What I did see, however, was a red spot, and this afterwards proved to be the dome of the State House. They were just putting on a new coat of goldleaf, and had painted the dome red preparatory to the finishing process.

It is very difficult, indeed, to describe the appearance of a large city like Boston when one is flying half a mile to a mile above it. Of course, you get an absolutely plain view. You see far below you a busy world just as when you are standing above an ant hill you see the little insects rushing to and fro about their labors. Far out in the harbor was a big steamer just coming into port, and I could tell by the steam coming from its whistle that they were signaling to me, although I could not hear them on account of the roar of my engine, and because I sit above my planes, and these act like sound reflectors, and throw the sound downward.

After sailing out over the harbor, I pointed my machine towards the Waltham aerodrome, and following the Charles River it was only a few minutes

The author rounding the State House Dome—First aeroplane flight over Boston

before I was back in Waltham again. To make the trip that I did, in an automobile, would have taken an hour and a half, and it took me just twenty-one minutes. When you appreciate the fact that I was making this remarkable trip in a mechanical device which was literally in its infancy, can you have any doubt whatever as to the future of the modern aeroplane? It is simplicity itself, is inexpensive to build, and is the speediest means of locomotion extant. As I said before, there is only one problem that stands before the universal use of the aeroplane, and that is the one of maintaining lateral stability. As soon as this problem is solved, the aeroplane will take its position among other means of transportation as a commercial proposition.

Speaking of the future of the aeroplane, I should like to say a few words. Will aeroplanes ever replace ocean liners and railroad trains? How long before the aeroplane will be made which will carry a hundred people with the comfort and convenience of the Atlantic liner?

I may be mistaken in my idea of the future of the heavier-than-air flying machine, but I do not think that it will ever be a vehicle for carrying a very large number of people. The automobile is essentially a means of locomotion for only a few people at a time, and I believe that the aeroplane will in this way prove similar.

It would be impossible for any of us, however great an imagination we might have, to form a very concrete idea of the aeroplane fifty years from now, but I believe we are safe in speculating as to what its position will be within the next five years.

Of course, the first use will come in war and in carrying light merchandise, such as registered mail, with the greatest speed and over the roughest countries.

As soon as the dangers of the aeroplane have been largely eliminated, that is, as soon as aeroplaning is made as safe as automobiling, I believe one of the first effects will be to extend the suburban area. In other words, a man will own

A Smash at Blériot's School, Pau, France. It was here the author learned to fly

his aeroplane, and either have his private hangar and aerodrome, or will house his machine in the public hangar and start from the public aerodrome. He will reside say fifty or a hundred miles from the large city in which his place of business will be located. In the morning his aero-chauffeur will take him with the greatest possible speed and with the least personal inconvenience to the outskirts of the big city. Here a descent will be made upon one of several public aerodromes which will be located on the outskirts of the great city. These aerodromes will be the terminals of the electric railroads, taxicabs, and other means of land locomotion.

Our business man of the future will now leave his aeroplane in charge of his aero-chauffeur, and go to his business either in his automobile or in one of the more prosaic lands methods. In the meantime his aero-chauffeur has taken the aeroplane into one of the hangars surrounding the big public aerodrome which hangar our business man may possibly rent by the month. A careful examination of the engine and the machine itself will be made preparatory to the trip home in the evening.

I do not believe that flying over large cities will be permitted as soon as aeroplanes become more common. However safe the aeroplane may be, there are times when it will fall suddenly to the earth, and it is not right to subject the residents of a populated district to such a danger. Even in flying back and forth from the aerodrome, I think that the route will be ever comparatively sparsely settled areas with perhaps emergency aerodromes every twenty miles or so.

I have always been an advocate of high flying. It is never the fall which hurts, but the sudden stop. Fly at the height of a mile and with a gliding angle of one in six, which is perfectly practical at the present time, you have a circle

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having a diameter of twelve miles upon which to land. If now, the emergency aerodromes are sufficiently numerous, there need be no danger whatever of making a landing upon other than a proper field. And I look to the great improvement of the gliding angle of the aeroplane. There is no reason why we should not obtain a gliding angle of one in twenty or better.

As far as the construction of the machine is concerned, I don't think there is a great future for the present aeroplane composed of wood, wire, and canvas. Sooner or later the all-steel aeroplane is going to be the only practical construction. The reason it is not at the present time is because weight is of such momentous importance, and wood is lighter than steel in proportion to its strength. With a further improvement in the lightweight gasoline engine, however, this matter of weight will not be of such importance, and then will come the all-steel aeroplane. And as I have already stated, I believe that ten horsepower will be all that is required to carry one man through the air on a heavier-than-air flying machine. Of course, a higher powered motor will be used, but only to obtain speed. It will not be necessary for sustention.

Believing as firmly as I do in the future of the aeroplane, I cannot do better than to conclude my remarks by emphasizing the fact that there is a great future for the aeronautic engineer. Most of the engineering professions are overcrowded at the present time. Here is a new science waiting for competent men to grapple with the problems it holds forth. Personally I am of the opinion that the young college graduate of today, and the graduate of the technical school, could do nothing better than adopt as his life's work the profession of aeronautical engineer. It's an old saying that "the early bird catches the worm," and I believe that the remuneration will be very great during the formative period of the new science of aerial locomotion. The time has arrived in the development of the heavier-than-air flying machine when the services of the expert engineer are required in order to carry the development to its logical conclusion. You young men who are casting about in an effort to decide which profession you will adopt, will do well if you give weighty consideration to the new profession of aeronautical engineering; it offers unlimited opportunities to the trained man with initiative. Incidentally the work is wonderfully fascinating.

THE RADIATION OF THE SUN

SOLAR RESEARCHES THAT MAY GIVE US A BETTER UNDERSTANDING OF THE FLUCTUATIONS OF TEMPERATURE, CLOUDINESS AND RAINFALL

BY C. G. ABBOT*

THE sun presents many interesting aspects. Although controller of the solar system, an object rich with beautiful and curious features, the nearest of the fixed stars, and typical of a large class among them, the sun also has a still greater claim on human interest as the fountain of heat, light and life upon the earth. It is this latter aspect which we shall consider mainly, still further confining our attention almost wholly to work done under the auspices of the Smithsonian Institution.

When James Smithson died in Genoa in 1829 he left his estate, subject to certain conditions, "to the United States of America, to found at Washington, under the name of the Smithsonian Institution, an Establishment for the increase & diffusion of knowledge among men." On May 9, 1838, by decree of the English Court of Chancery, the Smithson bequest, amounting to about $500,000 was adjudged to the United States. By the act of establishment in 1846, the control of the Smithsonian Institution is vested by Congress in a Board of Regents comprising the vice-president and the chief justice of the United States, three senators, three representatives and six private citizens. The Board perpetuates itself by election. In the years that have elapsed the Smithsonian private funds have increased by gifts and economy to nearly $1,000,000. For many years the institution has administered the annual congressional appropriations for the support of the National Museum, National Zoölogical Park, Bureau of American Ethnology, Astrophysical Observatory, Bureau of International Exchanges, and International Catalogue of Scientific Literature. The immediate administration is in the hands of the secretary of the Board of Regents, at present Dr. C. D. Walcott, the fourth of the secretaries.

Dr. S. P. Langley, the third secretary, a distinguished American astronomer, founded in 1890 the Astrophysical Observatory of the Smithsonian Institution, and was its director until his death in 1906. His own principal investigations, and those of the Astrophysical Observatory begun under his direction and still continued, have lain in the field of measuring the quantity and quality of the sun's radiation, the effect of the earth's atmosphere thereon, and the dependence of terrestrial temperatures and plant life on solar radiation. This is a utilitarian branch of astronomy, whose applications to terrestrial concerns may be expected to increase in future years and result in the promotion of the arts of meteorology and agriculture. But the interest of such studies for the promotion of pure knowledge is also very high. Let us imagine that the Greek philosophers, the Arabians, and the astronomers of Galileo's time, had all possessed the means to measure accurately the quantity and quality of solar radiation. How interesting it would be now to compare their measurements with our own, and determine thereby what, if any, appreciable changes have occurred in 2500 years in that energy which supports heat and life upon the earth! The astronomer of the future will have, we hope, trustworthy measurements of our own time to compare with his own. Referring to another branch of the measurements which I am to bring before you, our knowledge of the approximate temperatures prevailing in the sun, and our conclusions as to the sun's nature

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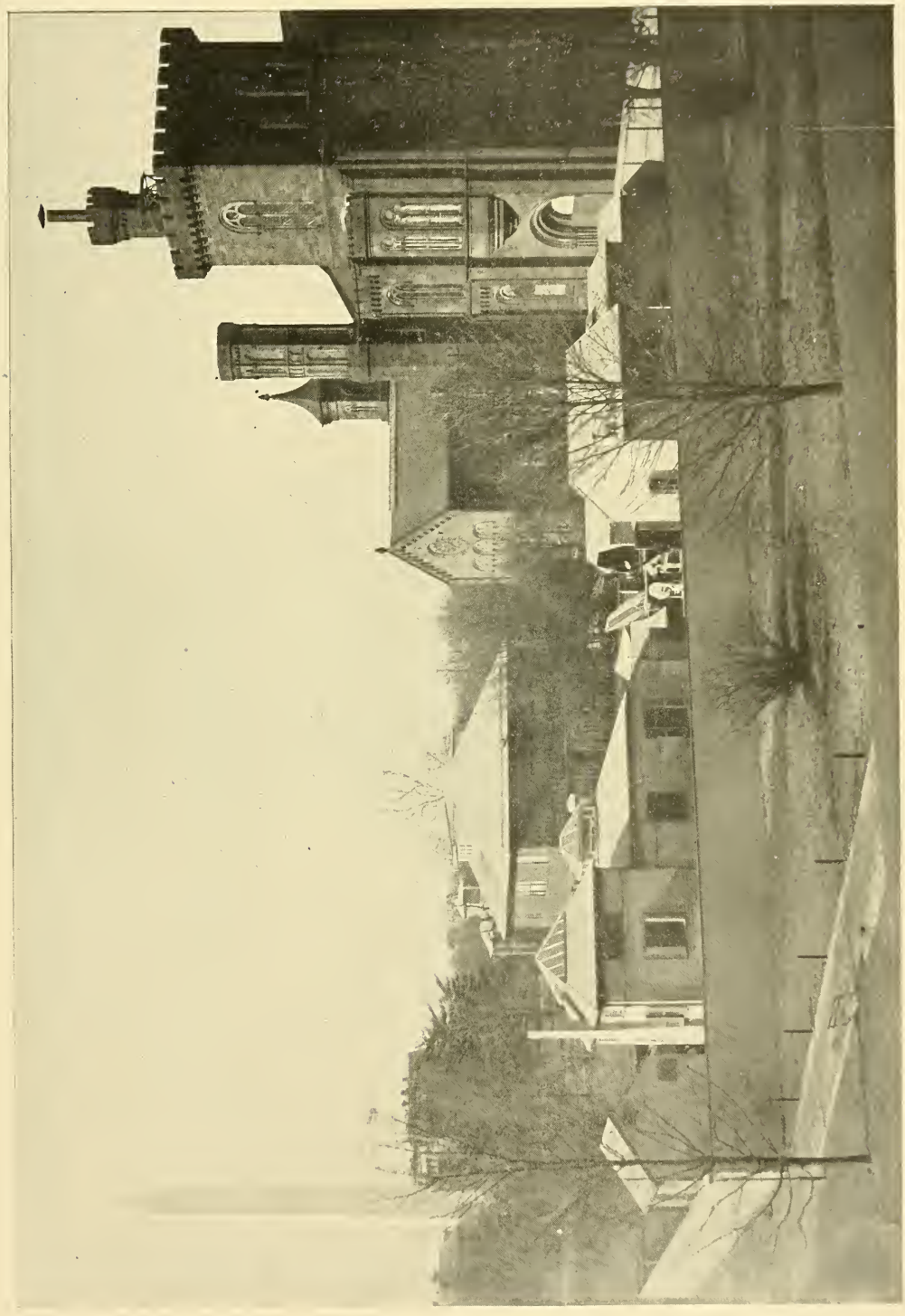


Smithsonian Institution, Washington

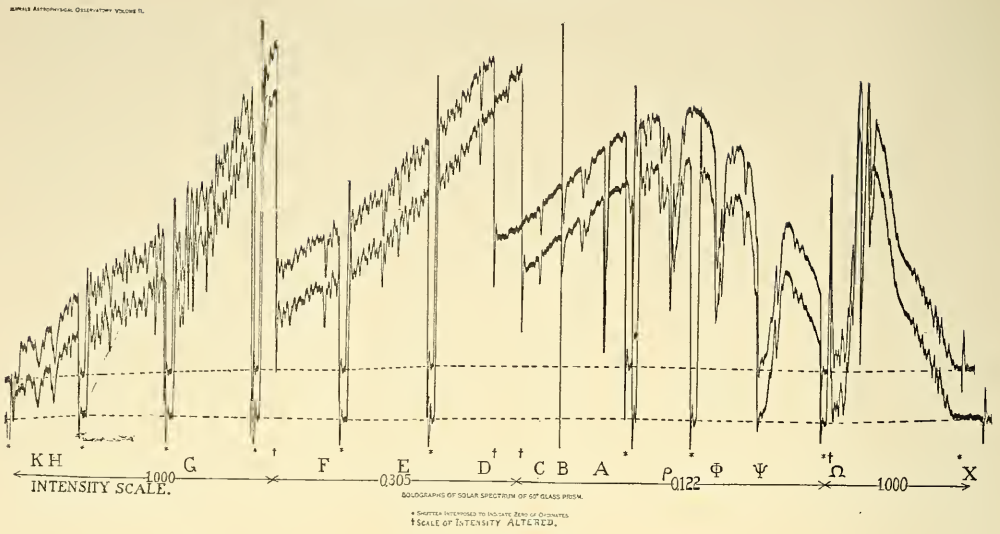


Plate 3, Fig. 1

rest on such work as is being done at the Smithsonian Astrophysical Observatory.

By the term solar radiation, I propose to your minds not only the solar rays which affect our eyes as light, but the extensions of the spectrum beyond the violet and beyond the red, where the eye is not sensitive. All these rays, whether visible or not, may be absorbed by blackened surfaces and will thus produce their just and proportional effects as heat. For the measurement of solar radiation, Langley, about 1880, invented the delicate electrical thermometer shown in Plate 2 which he called the bolometer; Fig. 8 of Plate 2 shows its most important part. This is a pair of tapes of platinum, each about 1 centimeter long, 0.01 centimeter broad, and 0.002 centimeter thick. These tapes are blackened with camphor smoke, or by a deposit of platinum black. One is exposed in the path of the rays to be measured, and the other is hidden. Hence one tape is warmed with respect to the other. Thereby a minute electrical current is caused to flow through the delicate galvanometer connected with the Wheatstone's bridge of which the tapes form two arms. In this way a change of temperature, which may be as small as one millionth degree Centigrade, may be detected in ordinary practise. By special devices the sensitiveness may be increased beyond this one hundred fold. But though so sensitive the bolometer is far behind the eye in its capacity to detect faint yellow light. It is used in preference to the eye because

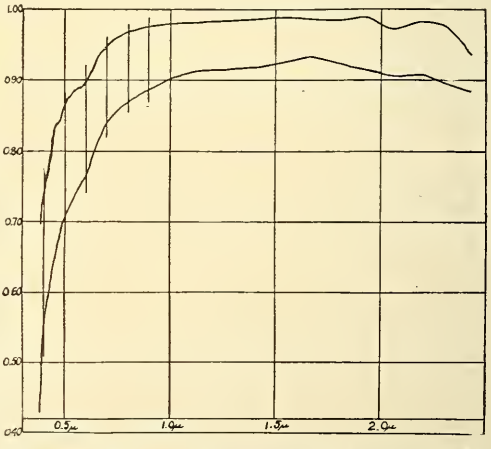


Plate 3, Fig. 2. Atmospheric transmission Mt. Wilson and Mt. Washington

it can detect and correctly measure the relative intensities of rays of all wavelengths whether visible or not.

The indications of the bolometer may be automatically observed by photography, and thereby the solar spectrum

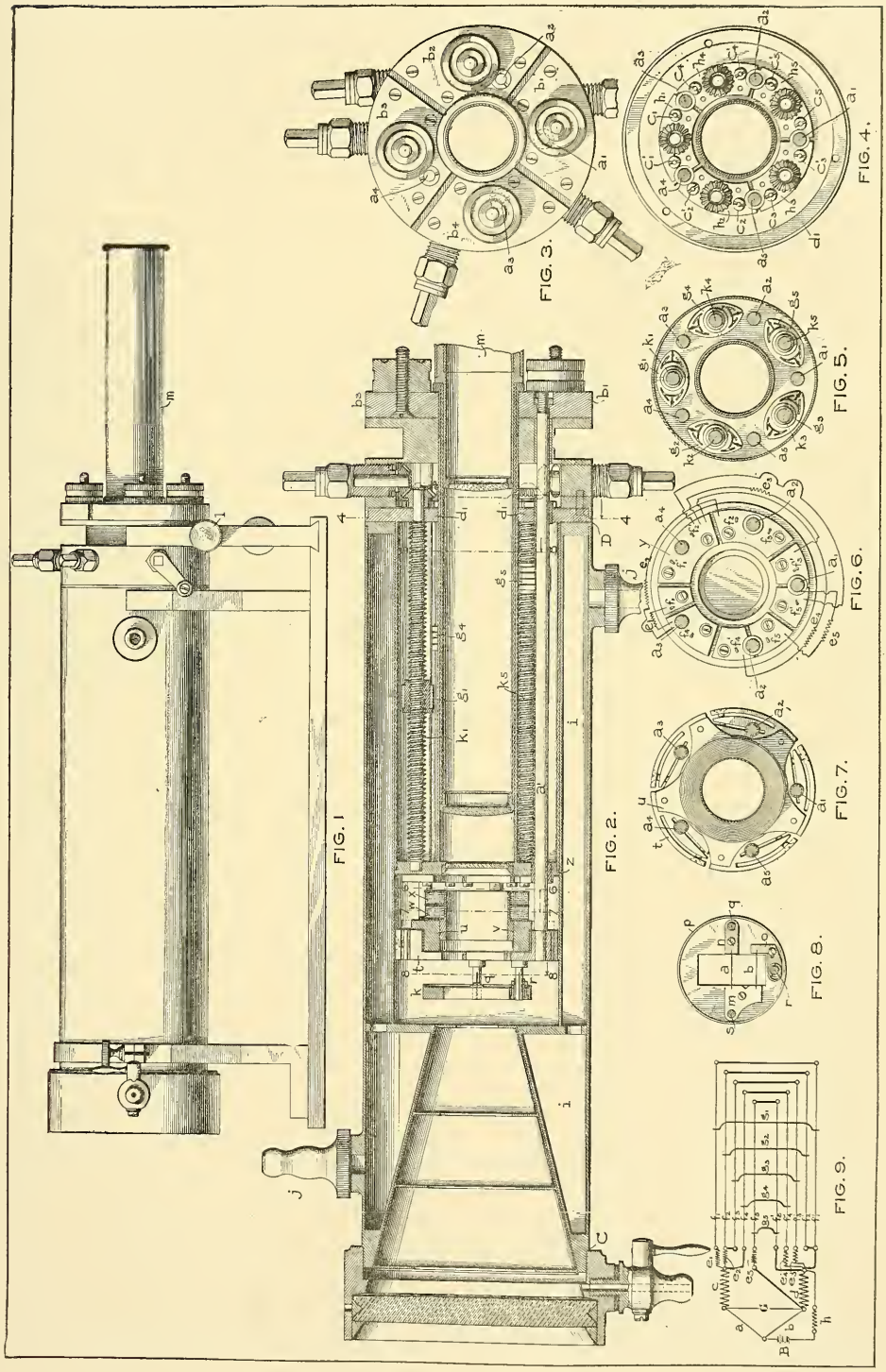


Plate 2, Fig. 8. Bolometer and its adjustments

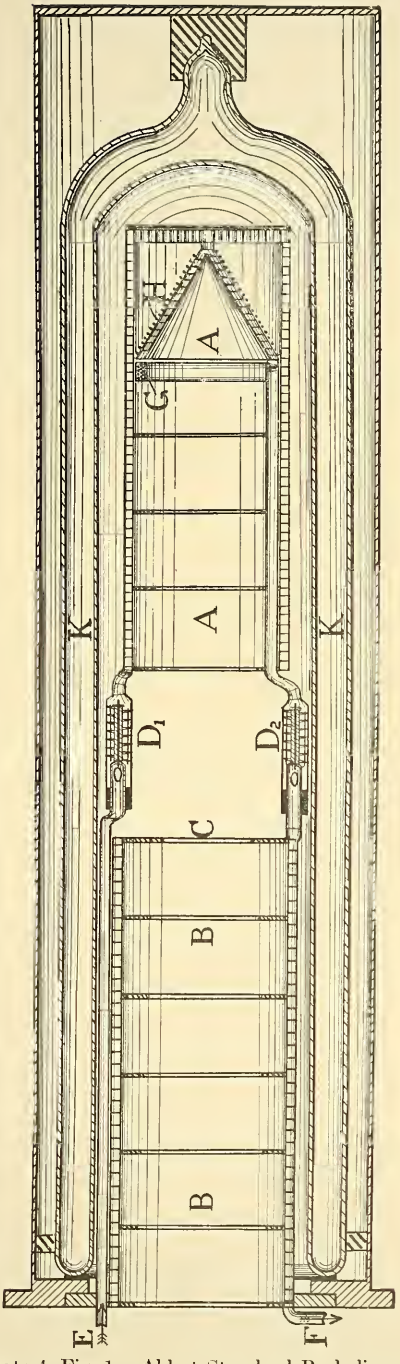


Plate 4, Fig. 1. Abbot Standard Pyrheliometer. Radiation falls on cone at A; Resistance thermometers at D_1 and D_2; Water flows in at E, out at F; G and H, coils for electrically known amounts of heat

may be exhibited, as in Plate 3, Fig. 1, as a sinuous line whose elevation above the base line of zero radiation gives the relative intensity of the different colored or invisible rays. The two curves shown are taken independently about an hour apart, for the purpose of studying the increase of intensity of the sun's rays of different wave-lengths as their path in air diminishes in length in consequence of the approach of the sun to the meridian. From such studies the results shown in Plate 3, Fig. 2, are found. The upper curve represents the percentage transmission of a vertical column of air above Mount Wilson (elevation 1750 meters) while the lower curve shows the less transmission for vertical rays at Washington (30 meters). The wave-lengths are indicated as abscissæ. From this we see how much more loss the violet rays of wave-length 0.40μ suffer than do the red rays of wave-length 0.70μ in traversing the air.

In order to determine the quantity of the solar radiation, we must fix our conditions independent of the variable losses in the atmosphere. We attempt, therefore, to make the observations in such a manner as to permit a correct estimate of the atmospheric losses, so that the result can be expressed as if the measurements were made in free space beyond the atmosphere. But of course our actual work must be done at the earth's surface. We express solar radiation in heat units called calories. As the bolometer is not of itself capable of giving true calories we have devised an instrument shown in Plate 4, Fig. 1, a standard pyrheliometer, so called. A is a chamber of nearly the dimensions of a large test tube, whose walls are hollow and adapted for the circulation of a stream of water. The stream enters at E, bathes the walls and rear of the chamber and the cone-shaped receiver of rays H and passes out at F carrying the heat developed by solar rays which enter the chamber by the measured orifice C. At D, and D_1 and D_2 are platinum coils adapted to measure the rise of temperature of the water due to solar heating. Knowing the weight of water per minute, the rise of temperature and

Plate 5, Fig. 1. Mt. Wilson Solar Observatory

the area of the opening C for solar rays, their intensity is determined. As a check, heat may be produced electrically in the chamber, and the proof of the accuracy of the instrument consists in finding the known quantity of electrically introduced heat correctly measured. Another simpler instrument for every day use is the Silver Disk Pyrheliometer shown in Plate 4, Fig. 2, which may be standardized against the water-flow instrument and in which the measurement is made by reading a thermometer at stated intervals.

In measuring the intensity of solar radiation as it would be outside the earth's atmosphere at mean solar distance (generally called the Solar Constant of Radiation) it is important to select a station where variability of atmospheric conditions is slight, and where the quantity of air traversed by the solar rays is small. Owing to smoke and clouds, Washington is a poor locality for the purpose, and so in 1905 an expedition in my charge was sent by invitation of Director Hale of the Mount Wilson Solar Observatory, to take station on Mount Wilson. Plate 5, Fig. 1, shows some of the gigantic apparatus erected by Director Hale at that fine site. With this remarkable outfit the work done by the Mount Wilson Solar Observatory Staff has been wonderfully productive. The Smithsonian Observatory on Mount Wilson, a little affair comparatively, is shown in Plate 5, Fig. 2. It was built in 1908 on a small plot of ground leased from the Solar Observatory. A cottage has since been built close by for observers' quarters.

In order to test more thoroughly whether we can indeed truly estimate the losses of solar rays in our atmosphere, work was done in 1909 and 1910 under my charge at Mount Whitney (4420 meters) the highest mountain in the United States. To further the work of this and other scientific expeditions, the Institution erected on Mount Whitney

Plate 5, Fig. 2. Smithsonian Observatory, Mt. Wilson

in 1909 the stone and steel shelter shown in Plate 6, Fig. 1. My apparatus is shown in Fig. 2. With Mr. Marsh of Lone Pine, I remained two weeks on the summit in 1909 and again in 1910, and made measurements of the solar constant of radiation there, while my colleagues made similar measurements at Mount Wilson. The following table shows the results:

	Sept. 3, 1909.	Aug. 12, 1910.	Aug. 13, 1910.	Aug. 14, 1910.
Solar constant:				
Mount Wilson.....	1.943	1.943	1.924	1.904
Mount Whitney.....	1.959	1.979	1.933	1.956

Taking the mean of the differences between the results obtained simultaneously at the two stations, it appears that the results obtained on Mount Whitney average 1.4 per cent. higher than those obtained on Mount Wilson. But considering that the optical apparatus used on Mount Wilson comprised a silvered glass mirror coelostat, an ultra-violet crown glass prism, and two silvered glass mirrors, while that on Mount Whitney comprised only a quartz prism and two magnalium mirrors, and, furthermore, that the pyrheliometers employed at the two stations were read at very different temperatures, it is probable that the slight difference found between the results may be due wholly to experimental differences and implies no discrepancy due to the difference of altitude between the two stations.

This conclusion seems worth emphasizing. We have now made simultaneously solar-constant determinations at sea level (Washington), at over a mile altitude (Mount Wilson), and again at Mount Wilson, and at nearly three miles

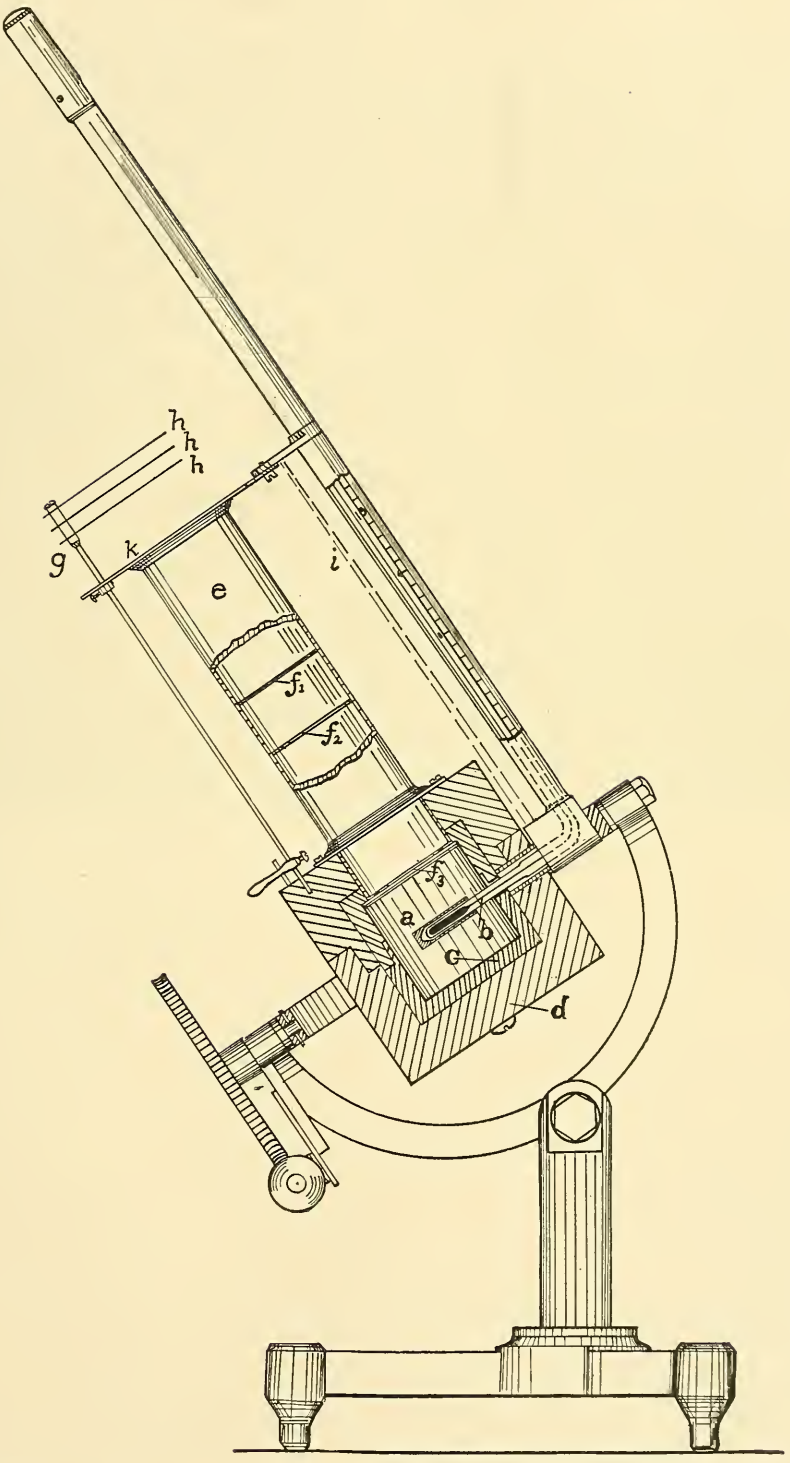


Plate 4, Fig. 2. The Abbot Silver Disk Pyrheliometer

Plate 6, Fig. 1. Pack train at Smithsonian Shelter, Mt. Wilson

altitude (Mount Whitney). Although both the quantity and the quality of the solar radiation found at these stations differ very much, neither the "solar constant" nor the distribution of the solar energy in the spectrum outside the atmosphere, as fixed by the wholly independent measurements at these three stations, differs more than would be expected in view of the unavoidable small errors of observation. We seem justified in concluding that we do, in fact, eliminate the effects of atmospheric losses and actually determine the true quantity and quality of the sun's radiation outside the atmosphere as we might do if we could observe in free space with no atmosphere at all to hinder.

Expeditions to Mount Wilson have now been made in 1905, 1906, 1908, 1909, 1910 and 1911 continuing from May until November. In the earlier years the observations were not made daily, but in 1908, 1909, 1910, and 1911 daily

	Washington.	Mount Wilson.					Mount Whitney.	
	1902–1907	1905	1906	1908	1909	1910	1909	1910
Times observed	44	59	62	113	95	*28	1	3
Mean value	1.960	1.925	1.921	1.929	1.896	1.914	1.959	1.956

*Other days of observation not yet ready. General mean, 1.922 calories (15° C.) per square centimeter per minute. Number of determinations, 405.

Plate 6, Fig. 2. Mr. Abbot's Apparatus on Mt. Whitney

determinations of the solar constant were made when possible. I give below a summary of this work up to the middle of 1910, and with it also the results obtained at Washington and at Mount Whitney.

We draw the conclusion that, for the epoch 1902 to 1910, an object in outer space, at the earth's mean solar distance, would have received radiation on surfaces at right angles to the solar beam at the mean rate of 1.93 calories per square centimeter per minute. What a prize would be given to one who could bring us similar measurements dating, let us say, from the time of Archimedes!

Before considering the possible variability of the sun we may pause to note some of the by-products of the solar constant measurements. Referring again to Plate 3, Fig. 1, we see before us the distribution of energy in the sun's spectrum observed at a particular time on Mount Wilson with certain apparatus. Knowing from other observations of the same day the losses suffered by the rays in the air, and being able to measure also the losses suffered in their passage of the optical apparatus, it is possible to compute the form which the solar energy spectrum would assume if observed outside our atmosphere, with perfectly transparent apparatus capable of forming a normal spectrum. Such a curve is that marked "All" in Plate 7, Fig. 1. It is marked "All" because it represents the mixture of rays from all parts of the sun's disk, just as we ordinarily get them. Plate 7, Fig. 2, shows a number of curves of distribution of rays along a diameter of the sun. From these we see that the sun's disk is not of equal brightness from edge through center to edge, and that the contrast of brightness is far greater the shorter the wave-length considered. In other words, the sun's edge is much

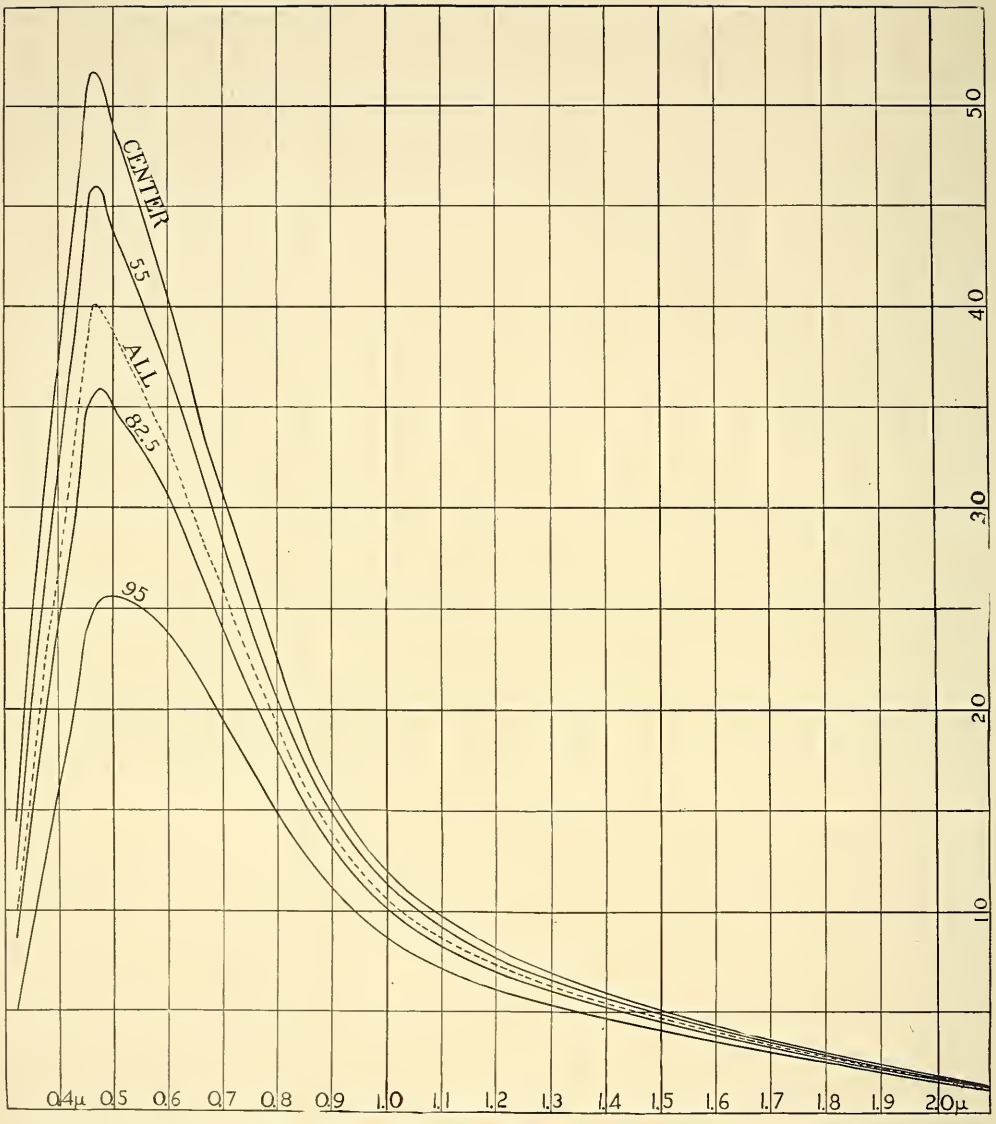


Plate 7, Fig. 1. Energy Spectra over sun's disk

dimmer compared to its center for the ordinary photographic plate than for the eye because the plate is most sensitive for violet and ultra-violet rays, while the eye is most sensitive in the yellow. Returning again to Plate 7, Fig. 1, the other curves show the relative intensities of solar energy of all wave-lengths taken from points distant zero 55, 82.5 and 95 per cent. respectively, from the center of the sun's disk. The intensities, as you see, diminish as we go out towards the sun's edge in all wave-lengths, but most rapidly for the shorter wave-length rays. Hence not only does the height of the energy curve alter, but its form changes, so that the place of maximum intensity shifts towards the red as we approach the sun's edge. This is a peculiarity of spectra of heated bodies at successively

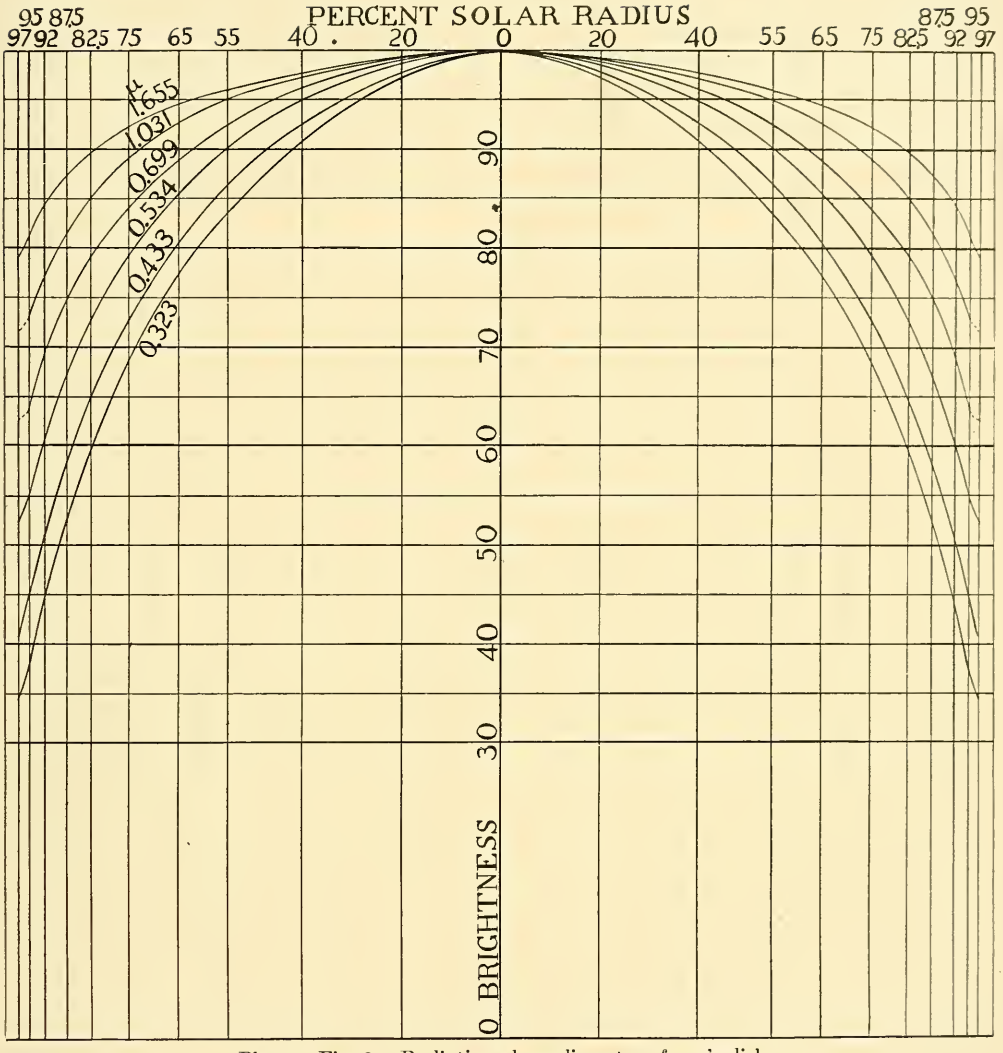


Plate 7, Fig. 2. Radiation along diameter of sun's disk

lower temperatures. It is quite reasonable to conclude that the light we see near the edge of the sun comes from regions of lower temperature than that which we get from the center of the disk. This is probably because our view is cut off before it penetrates very deeply, at the edge, because we are there looking very obliquely. Thus we see only superficial layers at the edge, and much deeper and hotter ones at the center. But all these temperatures are very much higher than any we know on the earth. The electric arc, for instance, is said to be at a temperature of about 3800° absolute Centigrade. From the form of the solar energy curve, the value of the solar constant, and other data, we estimate that the solar temperatures range from about 6000° absolute Centigrade upwards.

As the temperature of the earth depends almost directly on the quantity of solar radiation we are immediately interested to inquire if the sun, like so many others of the stars, is variable, and if so what corresponding variations

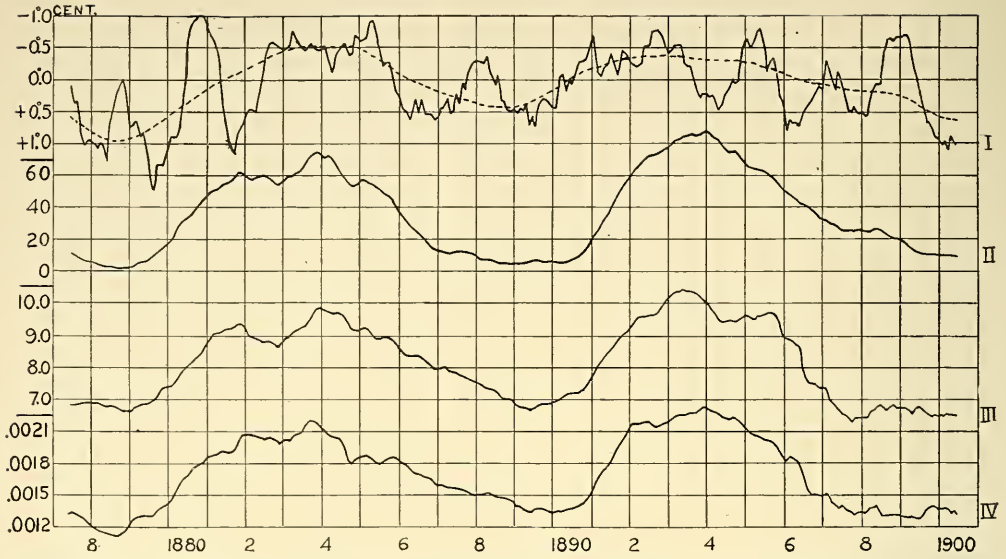


Plate 8, Fig. 1. Sun spots and terrestrial temperatures and magnetism. I. Departures of maximum temperature for United States. II. Sun spot members (Wolfer). III. Decimal range magnetic declination (Ellis; Chree). IV. Decimal range horizontal magnetic force (Ellis; Chree)

are produced in the temperature, cloudiness and rainfall of the earth. It has been known for over half a century that the sun has a slight variability of an average period of about 11 years, corresponding with the fluctuations of the number of sun spots, the changes in form of the solar, corona, and other solar phenomena, and inducing changes in the prevalence of the aurora borealis, the magnetic force and declination, and other terrestrial phenomena. Plate 8, Fig. 1, shows in its first curve the variation from normal of the temperature of the United States, second the variation of sun-spot numbers, third and fourth the fluctuations in terrestrial magnetic elements for the period 1878 to 1900. It would be of great interest if we had accurate solar constant measurements to compare with these changes for a long period of time. Unfortunately we have none such earlier than 1903 and only scattering measurements until 1905.

In Plate 8, Fig. 2, the results of solar constant measurements on Mount Wilson 1905 to 1909 are given. On their face they indicate a fluctuation of the intensity of solar radiation. The fluctuation extends over a total range of nearly 10 per cent. In the later years the measurements were made almost daily, and seem to bring out with certainty that the changes are not haphazard in their character. Successive days of observation indicate a gradual march of the solar constant values from a high to a low and back. Had the variations been due merely to accidental errors we should not have expected this regularity. Hence we conclude that the changes observed are either really solar or are due to some obscure source of error in estimating the losses in our atmosphere. The latter supposition is not very reasonable because as already shown we get practically identical solar constant values whether we observe at sea-level (Washington), 1 mile (Mount Wilson), or 3 miles elevation (Mount Whitney). Hence it seems most probable that we have found a real variation of the sun, irregular in amount and period, but of an average period of 7 to 10 days, and an average magnitude of 3 to 5 per cent. This would be "important if true"!

To test the supposed variability of the sun conclusively an expedition under my charge occupied the station Bassour in Algeria from July to November 1911,

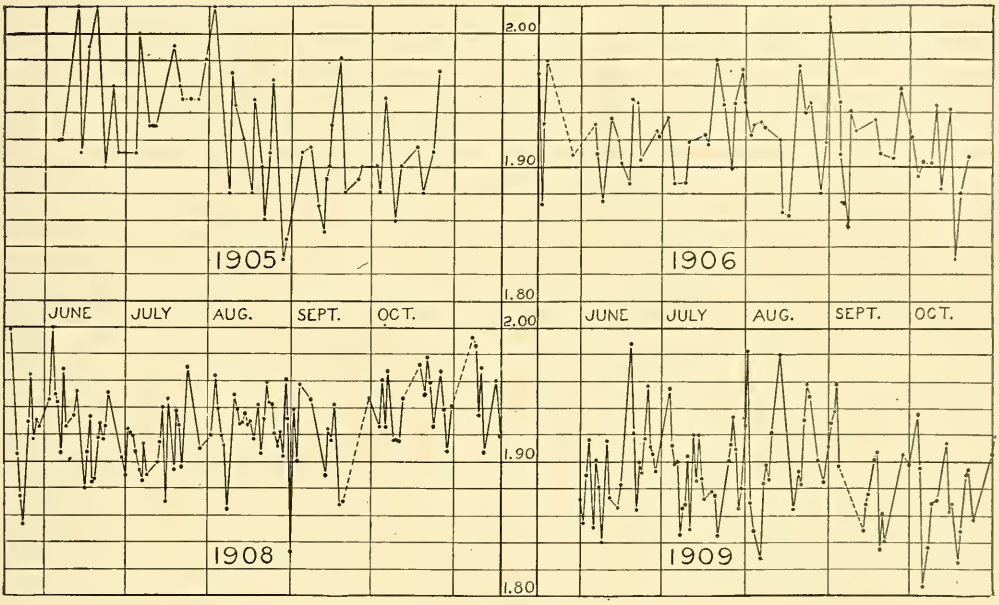


Plate 8, Fig. 2. Variations of the sun

and made there spectrobolometric determinations of the solar constant of radiation on every fair day while my colleague Mr. Aldrich made similar studies on Mount Wilson in California, distant about one third the earth's circumference. The observations are now being reduced, and we expect to know very soon whether or not the sun is really a variable star of short period. If it proves to be so, I venture to think that the result will be regarded as of so much interest that observatories in various parts of the world will take up the work of daily measurements of the solar constant of radiation. If the sun varies in this way we may, I think, reasonably hope that the knowledge of its fluctuations will enable meteorologists to understand better the fluctuations of temperature, cloudiness and rainfall.

THE USE OF OZONE IN BREWING

Ozone has now been brought forward as an aid to the production of better beer. Trouble with the fermentation not infrequently arises from an interference with the normal growth and activity of the yeast plant by the multiplication of certain bacteria. The result may be turbidity and lack of keeping quality in the final product. Experiments now show that yeast can withstand administrations of ozone which are fatal to the bacteria, and that the yeast can absorb and store the ozone to a considerable degree, giving it up only gradually. The application is obvious:—the purification of yeast by ozone and the use of such yeast in the fermentation. The results are represented as satisfactory, a beer being produced of normal taste and clarity and with much greater keeping power. F. S., JR.

MEMORY OR REFLEX ACTION?

M. Oxner finds that when a red cylinder containing food, and an empty green cylinder were placed in an aquarium a fish very quickly learned to enter the red cylinder each time it was immersed and avoided the green one. He further found that the fish would enter the baited red cylinder when the factor of hunger was eliminated, thus indicating habit or reflex action.

ANTICIPATING BUSINESS CONDITIONS

THE STUDY OF BUSINESS STATISTICS THAT HAVE BEEN GATHERED FROM WORLD-WIDE SOURCES WILL HELP THE MERCHANT TO DISCOUNT THE FUTURE

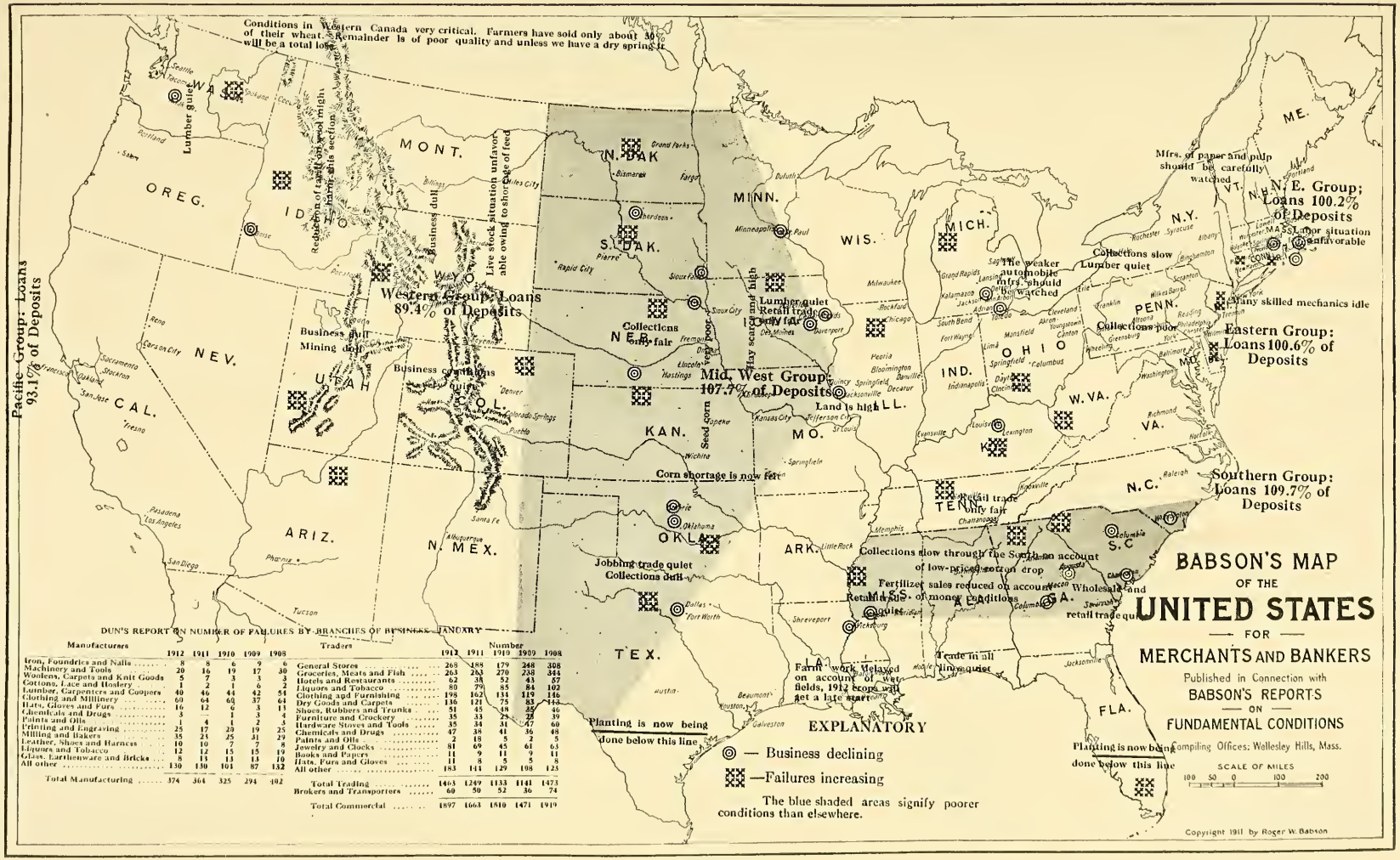
BY ROGER BABSON

When a man is ill and goes to his physician, he really is not very much interested in the diagnosis of his existing condition. The question he asks is, "How soon am I going to get well?" What he is really wishing to know is how the present condition is going to affect his future health or happiness. The merchant in business, asking for the statement of some customer desiring credit, really does not ask for it for its own sake, but for the purpose of determining how the customer is drifting. He is vitally interested in the tendency towards better or worse of that customer. The same principle is a ruling one through all departments of life. The interest seems to be in the present, the facts demanded are of the present, but the true position in studying the facts of today is that their bearing may be established on the events of tomorrow. There is business interest in anticipating what effect these facts will have on the future prices of commodities.

The first requisite is a knowledge of conditions in all sections of the country

Now, the art of forecasting business conditions is really no different than the forecasts of the attorneys, or the physicians, or the credit men. The work really consists of two essential steps; an accurate knowledge of conditions in all sections of the country, indeed of the world and the study of these conditions as the weather bureau studies the movements of storms and areas of different barometric pressure. There is a tendency for the Boston merchant, especially he who sells only to Boston people or people in New England to think that the money he receives comes from Boston or vicinity. This is an error. Although the customers may be Boston people, nevertheless only a small portion of the money which they bring in comes directly from Boston sources. Much of it is from the cotton fields of the South, the cattle ranches of the Southwest, the mining camps of Montana, Utah and Arizona, the wheat fields and corn fields of our great Western country, the fruit orchards of the Pacific Coast, and the steel centers of Pittsburg, Bethlehem and Gary. Therefore, the future of even local Boston business depends not so much on conditions in Boston as upon the conditions in the South, the West, the Northwest and the Eastern Central States.

Therefore, to aid the wise merchant and manufacturer in anticipating business conditions, we first prepare for him a map of the country showing conditions in all sections. (Chart I). In fact, two maps of the United States are prepared and issued by us every two weeks, both of which are usually mailed to the president or general manager, personally, of the corporation which employs us. One of these is known as the "Optimistic Map," showing where business is best, where failures are fewest, where the crops are the most prosperous and where the various other conditions are such as to attract trade. If a corporation or firm does other than a local business, the president may hand this map to his sales-manager and advertising man so that the routing of the salesmen, the distributing of the advertising and all other work connected with the extending of sales may be centered on that part of the country where the greatest opportunity exists. In other words, such a map serves primarily to give the head of the business a comprehensive view of condi-


Conditions in Western Canada very critical. Farmers have sold only about 30% of their wheat. Remainder is of poor quality and unless we have a dry spring it will be a total loss.
Lumber quiet
Reduction of tariff on wool might harm this section
Business dull
Live stock situation unfavorable owing to shortage of feed
Western Group: Loans 89.4% of Deposits
Business dull
Mining dull
Business conditions quiet
Pacific Group: Loans 93.1% of Deposits
Collections only fair
Lumber quiet
Retail trade only fair
May scarcity of high priced meats cause a falling off in consumption?
Mid. West Group 107.7% of Deposits
Land is high
Steel corn
Corn shortage is now felt
Jobbing trade quiet
Collections dull
Farm work delayed on account of wet fields, 1912 crops will get a late start
Planting is now being done below this line
Trade in all lines quiet
Collections slow through the South on account of low-priced cotton crop
Fertilizer sales reduced on account of money conditions
Wholesale and retail trade quiet
Retail trade only fair
Southern Group: Loans 109.7% of Deposits
Mfrs. of paper and pulp should be carefully watched
N. E. Group; Loans 100.2% of Deposits
Labor situation unfavorable
Collections slow
Lumber quiet
The weaker automobile mfrs. should be watched
Many skilled mechanics idle
Collections poor
Eastern Group: Loans 100.6% of Deposits
EXPLANATORY
— Business declining
—Failures increasing
The blue shaded areas signify poorer conditions than elsewhere.
BABSON'S MAP OF THE UNITED STATES
— FOR —
MERCHANTS AND BANKERS
Published in Connection with
BABSON'S REPORTS
— ON —
FUNDAMENTAL CONDITIONS
Compiling Offices: Wellesley Hills, Mass.
SCALE OF MILES
100 50 0 100 200
Copyright 1911 by Roger W. Babson

DUN'S REPORT ON NUMBER OF FAILURES BY BRANCHES OF BUSINESS—JANUARY

Manufacturers	1912	1911	1910	1909	1908
Iron, Foundries and Nails	8	8	6	9	6
Machinery and Tools	20	16	19	17	30
Woolens, Carpets and Knit Goods	5	7	3	3	3
Cottons, Lace and Hosiery	1	2	1	6	2
Lumber, Carpenters and Coopers	49	46	44	42	54
Clothing and Millinery	60	64	60	37	64
Hats, Gloves and Furs	16	12	6	3	13
Chemicals and Drugs	3	—	1	3	4
Paints and Oils	1	4	1	2	3
Printing and Engraving	25	17	20	19	25
Milling and Bakers	35	24	25	31	29
Leather, Shoes and Harness	10	10	7	7	8
Liquors and Tobacco	12	12	15	15	19
Glass, Earthenware and Bricks	8	15	13	13	10
All other	130	130	101	87	132
Total Manufacturing	374	364	325	294	402

Traders	1912	1911	1910	1909	1908
General Stores	268	188	179	248	308
Groceries, Meats and Fish	263	263	270	238	344
Hotels and Restaurants	62	38	52	43	67
Liquors and Tobacco	80	79	85	84	102
Clothing and Furnishing	198	162	134	119	146
Dry Goods and Carpets	136	121	75	83	116
Shoes, Rubbers and Trunks	51	45	48	45	46
Furniture and Crockery	35	33	29	22	39
Hardware Stoves and Tools	35	34	31	47	60
Chemicals and Drugs	47	38	41	36	48
Paints and Oils	2	18	5	2	5
Jewelry and Clocks	81	69	45	61	63
Books and Papers	11	9	11	9	11
Hats, Furs and Gloves	11	8	5	5	8
All other	183	141	129	198	125
Total Trading	1465	1249	1133	1141	1473
Brokers and Transporters	60	50	52	36	74
Total Commercial	1897	1663	1510	1471	1919

Number

Chart 1

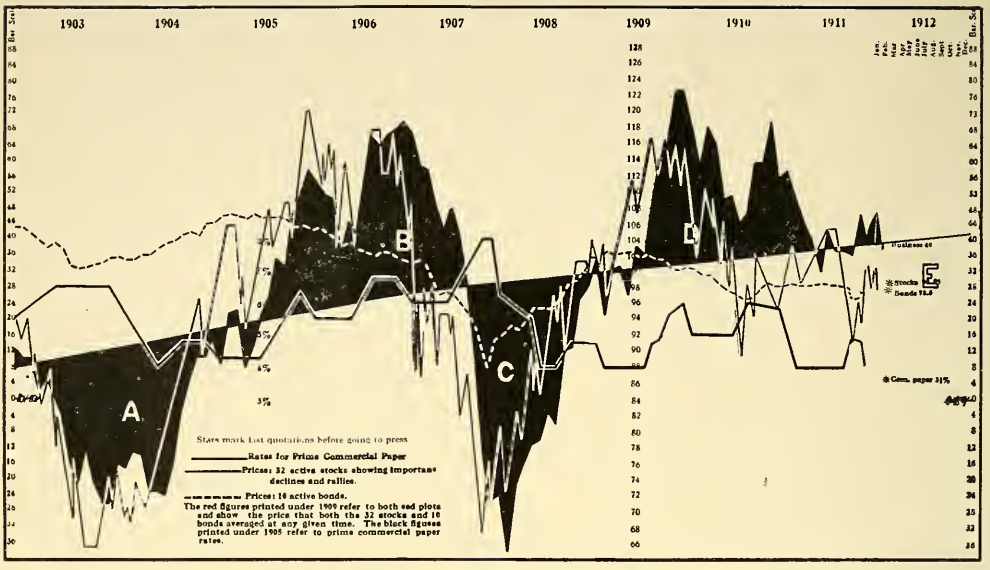

1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
A
B
C
D
Stars mark last quotations before going to press
Rates for Prime Commercial Paper
Prices: 32 active stocks showing important declines and rallies.
Prices: 10 active bonds.
The red figures printed under 1909 refer to both red plots and show the price that both the 32 stocks and 10 bonds averaged at any given time. The black figures printed under 1905 refer to prime commercial paper rates.

Chart 2

tions throughout the entire country. It is supplemented by detailed reports. Such maps and reports are supplying business news months before it appears in the public press and magazines.

In addition to this map, another is prepared which is also sent to the head of the corporation or firm showing the dark side of business, which may be termed the "Pessimistic Map." This indicates where business is poor, where the crops are uncertain, where failures are on the increase, and where credit conditions should be especially watched. Here again, if the corporation does other than a local business, the president can make further use of this map by turning it over to his credit department, enabling it to avoid the unfair and harmful system of "shutting down" on every body in all sections of the country to the same extent.

Instead of this the credit department may contract credits in one part of the country and possibly expand them in another section in a common sense and legitimate manner.

But although these maps are very useful for the purposes suggested above, yet their great value as an aid to the merchant is in anticipating future changes. Every period of depression and every period of prosperity which this or any other country has ever experienced has originated in some small section and spread in one or more directions from it. For this reason the merchant should keep in touch with business conditions the world-over. To illustrate some of the world-wide relations it may be interesting to see what the conditions are today (February 1912) in different places.

At the present time the greatest prosperity exists in Germany, and here is an abnormal condition liable to break like a bubble at any time; while the low pressure area, so to speak, is in our own country in a belt west of the Mississippi River, including the Dakotas, a part of Minnesota, extending down through Oklahoma into Texas and beginning to creep into the South. Whether or not we in this country are to have a panic or a depression cannot be told at the present time; but these conditions can be anticipated by studying the movement of such areas and noting whether the conditions in Germany break with a crash or whether they are gradually liquidated, whether the depression area throughout a portion of our West will work itself out in the South, or whether it will strike northward

to include Pennsylvania, New York and New England. The point that should be emphasized is that these changes can be anticipated by ascertaining conditions in different sections of the world at any time and the noticing the movements of the areas of low pressure and high pressure.

The Second Requisite is a Knowledge of the Volume of Business Including all Lines

In order to insure correctness in his forecasts, the successful merchant checks his conclusions as determined above by studying the volume of business, including all lines of trade. The money which you Boston merchants receive over your counter comes from other lines of business; the goods which you sell at a profit are sold to people in business different from your own. Therefore, your profits depend upon the prosperity of other lines rather than on the line in which you are directly interested.

Now, for obtaining a composite view of conditions in all lines, the merchant and manufacturer can take the figures on twelve leading subjects such as new building, bank clearings, immigration, failures, foreign trade, gold movements, crop statistics, idle cars, etc. The busy man, however, has not the time to pore over these figures, but desires to have them combined which is done in the Composite Plot of Business Conditions. (Chart II) This Composite Plot is in reality a trial balance of the United States, everything above the inclined line representing abnormal expansion, over-production, in fact the debit side of the ledger; while everything below the line represents contraction, rest, and the other items appearing on the credit side of the ledger. The outlines of the black areas represent the trend of business in this country and the last point at the right shows exactly where we are today. In other words, it may be seen that at the present time business is neither good nor bad, but it is poorer than it was a year ago, two years ago and three years ago, but much better than four years ago. In short, the Composite Plot of Business Conditions shows each week the volume of business being done throughout the country in all lines, the same as the maps show financial conditions in all sections.

Moreover, as by studying the movements of areas on Chart I one is able to anticipate changes, so by studying the variation in the volume on this composite plot from week to week, one may likewise anticipate conditions. This is owing to the fact that the law of action and reaction which applies to mechanics, medicine, astronomy and every other science applies also to business. Therefore for all that we go above the line of normal growth, there must be a corresponding amount—in area—below it. With this great principle firmly in mind and the charts in hand the merchant and manufacturer may anticipate with certainty the great trade tendencies.

As to what is to happen this week or next, or even this month or next, no one knows. You or I may apply to a life insurance company for a policy today, and we may be examined and shown to be in perfect health, and yet before night be run down by an automobile and killed; but when the insurance company considers all of its risks it can forecast with absolute certainty almost to a day what will be the average life of its policy holders, and it is the same with business. What will be the condition of your individual business, the next year or two, no merchant nor manufacturer can tell; but if he will take all of the business men together and treat them as one mass, the merchant and manufacturer who studies fundamental conditions, who studies conditions in all sections, and the total volume of all lines can tell with certainty by the use of these maps and these composite plots what will be the average business conditions.

On a clear day an object one foot above the level can be seen one and one third miles away. An object ten feet high can be seen at a distance of four miles.

CONSERVATION AND RESEARCH

LIGHT ENERGY AT HALF THE FORMER COST—WORK OF CANADIAN BUREAU OF MINES ON SMELTING IRON AND BRIQUETING PEAT—UTILIZING SMELTER GASES

BY H. T. KALMUS

STUDIES of conservation may be divided into two classes: those which pertain to wastes in connection with obtaining raw materials, and those which pertain to treatment and adaptation of these raw materials to utilize them as efficiently as possible. The former of these has received widespread attention, but the latter, which is essentially the work of the physical, the chemical, and the metallurgical research man, has been very little discussed. It is the purpose of this article to indicate some of the many ways in which the research laboratory has played an important part in conservation.

Most of the materials extracted from the earth have been exploited for thousands of years. However, the drafts upon the reserves of the earth as compared with its total capacity were small until the beginning of the nineteenth century. From the dawn of civilization until that time the amounts of fuels and metals mined had been so inconsiderable that it was thought that they would last through the indefinite future. Toward the latter half of the nineteenth century, began the age of scientific advance and invention, and of industrial and commercial operation on a large scale. Forecasts of the life of mineral resources made prior to that time became worthless in view of the tremendous acceleration at hand. Indeed, on this continent the output of the all-important products, coal and iron, has doubled in less than ten years which, computed in another way, means that the output of the first decade of this century has been more than that of all previous decades.

In his presidential address before the British Association for the Advancement of Science, Sir William Ramsay showed that, if the present increase in the output of coal mines in the British Isles continued, the supply would be exhausted in 175 years, a very brief space in a nation's life. We may no longer regard our coal supply as unlimited. In the year 1910 there were mined about 1300 million tons of coal. Of this, over 40 per cent. was produced on this continent and yet, according to Dr. J. A. Holmes, director of the United States Bureau of Mines, more than 2,000 million tons of anthracite coal and more than 3,000 million tons of bituminous coal have been left underground in such condition as to make its future recovery doubtful or impossible.

That there is tremendous waste in the mining of fuel supplies in North America is generally recognized, but its magnitude is almost inconceivable. In the mining of coal it is probable that scarcely 50 per cent. of it is removed from the ground and brought into such a form that it can be economically utilized. That portion which is left behind is undoubtedly lost forever, for the mines are allowed to cave in and probably can never be reopened. Of the need of this type of conservation we hear much in various reports, and the public at large are informed and are responding with liberal support in the movement towards betterment. But of the total energy in the portion of the coal made available for use, probably not over 11 per cent. is effectively utilized. The remainder of the energy is lost through the inefficiency of the steam boiler, the steam engine, and the electric dynamo. It is estimated that boiler scale on the locomotives of this continent alone, means an annual loss of over 16,000,000 tons of coal. One-sixteenth of an inch of boiler scale means a loss of 13 per cent. in efficiency, and one-eighth of an inch of

boiler scale, which occurs in many boilers, means a loss of 25 per cent. in efficiency. Here the research man directly effects an important conservation, although in such a way as not to be generally noticed, for an isolated investigator studying the chemistry of the deposition of boiler scale in his laboratory, is touching vitally the efficient utilization of our coal supplies.

Coal is being conserved by a great variety of heat insulating materials for lagging pipes, etc., which the chemist and the metallurgist have of late produced. The recent work of Dr. W. R. Whitney and his co-workers at the research laboratories of the General Electric Co., on the metal tungsten, has brought about an enormous conservation of coal resources. Until within recent years tungsten was considered a rare metal. Of late, because of its extremely high melting point, it became valuable as a substitute for platinum in the chemical laboratory. Now we find tungsten being drawn into fine wires for the manufacture of incandescent lamps on a colossal scale. In this way not only is the power consumer benefitted by the fact that replacing the old carbon filament with tungsten he gets the same amount of light energy at one-half the cost, but we have at the same time a direct wholesale saving of coal.

It is interesting to note the way in which researches on tungsten have effected real conservations in other ways. This hitherto almost worthless element has been found, when properly formed, to have properties far superior to those of any known metal for the manufacture of X-ray tubes. In modern X-ray practice powerful electrical apparatus is used to excite the tube. The greater part of the energy delivered to the tube is transformed into heat at the point where the cathode rays bombard a metallic target. Where platinum is used, which melts at 1755 degrees centigrade, it has been found necessary in order to prevent melting to place the target beyond the focus of the cathode, so as to spread the bombardment over a larger area. Without going into detail, this means at best an E-ray picture with poor definition due to the danger of melting the platinum. Tungsten, with a melting point of 3000 degrees centigrade, permits of sharp focussing of the rays on the target and of the use of more energy through the tube and, consequently, of a shorter exposure than has been hitherto possible. Aside from the direct value of this research on humanity, it obviously will substitute a new metal for the very limited and most costly one hitherto used, platinum, thus conserving the platinum for other uses where it alone can fulfil the requirements. The significance of this becomes obvious when we reflect that the production of platinum on this continent fell off about one-third during the past two years.

Ages ago there were stored up, chiefly by the influence of plant life, immense deposits of carbon and nitrogen, which have made modern civilization possible. Some of this nitrogen may have been compounded to its present useful form by electrical discharges in the atmosphere, but it is highly probable that the larger portion of it was formed of bacterial action. Certainly it appears to be true that the 500,000,000 tons of sodium nitrate, which are known to be deposited in the desert of Atacama, Chili, are of organic origin from plants and animals whose refuse, under peculiar conditions of heat and water supply, was oxidized and collected in this unique locality. Until recently we have drawn from these deposits practically our total supply of the element nitrogen, which is absolutely essential for both plant and animal food. Besides, we have drawn from this source all of the nitrogen without which we could not have explosives, upon which depends the whole of our mining industry. Our waste of nitrate as fertilizer has so impressed the human mind that the daily press for years has pointed out the possible starvation of man because of the inability of the earth to supply nitrate for plant life. 2,600,000 tons of sodium nitrate have been taken each year from Chili, which means that the depletion of these deposits is less than a century away. Yet, in the manufacture of coke, for the

various industries, but $3,800,000 worth of $160,000,000 worth of recoverable nitrogen which the original coal contained, was saved. The balance went off into the air as free nitrogen.

This nitrogen, among other things, is saved by the Germans under similar conditions, as the result of their researches. Until recently, practically all the coke made on the North American continent was produced in the old bee-hive type of coke oven, so called because of its similarity in shape to the conventional bee-hive. In this oven the coal is only partly consumed or, more accurately, the volatile combustible constituents, the gas, tar and ammonia, everything except the fixed carbon which is left behind as coke —is wasted. In comparatively recent years, a vast amount of research has been carried on in Germany, the outcome of which has been the saving of these various products by the development of the by-product oven, and the wonderful coal tar industry. This industry, which is probably the greatest example of chemical industrial progress, has as yet not been developed on this continent. It effects conservations in many ways; not generally noticed, but noteworthy among them, by producing an endless variety of dyes and coloring substances. All the aniline dyes are made from distillation products of coal. These formerly required rich land, now devoted to other purposes. Indigo alone, now prepared from coal tar, is equivalent to over 300,000 acres of indigo plants.

The research chemist has made possible the utilization of these by-products of the coke industry. He has, until recently, been appreciated only in Germany, but this continent is fast awakening to the reality of Germany's industrial progress, and research laboratories are making their appearance at the works of most of our progressive producers.

Passing to one of the largest of the industries, the iron and steel industry which produces, annually, on this continent over 20,000,000 tons of steel, we find that there is a loss of metal by oxidization during the metallurgical process which probably aggregates 1,000,000 tons. Along with this loss of iron many other elements more valuable than iron, which are needed in the final product, are burned out. When we contemplate this enormous amount of material and when we further contemplate that the production of the crude pig iron for this amount of steel represents an annual consumption of more than that many tons of coke, the importance of research to effect the most minute economy becomes obvious. The modern trend has been to study the possibilities of producing pig iron and steel in electric furnaces, the result of which is that considerable high-grade steel is now being made in this way. The Canadian Bureau of Mines, under the direction of Dr. Eugene Haanel, studied at length the production of pig iron from ore in electric furnaces and, as a result of this pioneer investigation, extensive work among the same lines was conducted at Trollhätten, Sweden, by the Swedish Iron-Masters Association. These experiments seem to show conclusively that where water power is cheap a conservation may be effected, and both pig iron and steel successfully manufactured on a commercial scale in electric furnaces.

Formerly, most of the slag from the iron and steel furnaces also went to waste, but in 1910 over 7,000,000 barrels of cement were produced on this continent from these slags. The Portland cement industry has had a tremendous effect upon the conservation of our natural resources, for not only has it supplied a cheap material to replace iron for many structural purposes, but it is also used as a coating to iron and steel, greatly increasing its life by preventing rusting. It is also taking the place of millions of feet of lumber, the demand for which of recent years, has been so rapidly depleting our forests.

A treatise may be written on conservation in connection with the iron and steel industry alone, but I wish only to point out a part played by the research man, which is not ordinarily apparent to the average reader. Where formerly carbon steel was used for certain electrical machinery, it is known that steel con-

taining a few per cent. of the element silicon will do the same work at a very substantial reduction in the power consumed. Here we have one of the most widespread of the elements, silicon, and one which, from a commercial point of view, is a drug on the market introduced in small quantities in a refined product to produce a steady permanent saving at the coal bin.

Professor G. Cotterell has spent years at painstaking research to produce a process for the electrical precipitation of suspended particles. The conservations that are being brought about by means of this are incalculable. Several large copper smelters in the western part of the continent were forced by the government to close down, owing to the devastation of the surrounding country from their sulphur fumes. One smelter alone in California emitted 250-500,000 cubic feet of poisonous gas per minute. It has adopted this new electrical process to the full capacity of its plant, and is now not only in a position to operate without injury to others, but it can save this flue gas for the production of sulphuric acid. Prof. C. L. Parsons, of the United States Bureau of Mines, points out that we discharge into the air from a single stack of the Washoe smelter, as much sulphuric acid as is utilized throughout the whole of the country, and yet this same acid is the basis of all chemical industries and of the manufacture of fertilizers.

Another recent development which promises much is that of the fixation of atmospheric nitrogen by the energy of the electric discharge. In this way there is made a compound of nitrogen available for use as fertilizer. Although this process is as yet rather inefficient, due to its high temperature and attendant heat loss, nevertheless, even this first approximation at a process has been eminently successful, reporting net earnings of $350,000 for the year 1911. It would certainly seem that if bacteria can bring about the fixation of nitrogen in the small laboratory they utilize at the roots of the legumes, man must sooner or later succeed in bringing it about at moderately low temperatures in his laboratories.

Only three years ago a leading scientific mind said, "The crest of our known resources of highest grade copper is already passed, and we are using lower and lower grades with increasing cost of production. The increasing inadequacy of our copper supply is a matter of deep concern." So rapid, however, has been the progress in the metallurgy of low-grade copper, that it is now proving more profitable to work than was previously the case with the high-grade ores. Indeed, although our production of copper has increased about 1000 per cent. in the last 25 years, and the annual output and consumption is still increasing, yet prices are lower than they were three years ago. This must all be credited to the greater efficiency of metallurgical processes making possible the utilization of deposits formerly supposed to be worthless.

Even this brief review of some of the important points at which the investigator touches the problems of conservation would be incomplete without mention of the recent and present work of Dr. Eugene Haanel and his associates of the Mines Branch, Ottawa, on peat. Peat is a material found in extensive bogs, in nearly every province of Canada. As removed from the bogs it is unsuitable for use as fuel, but after special treatment, including drying and briqueting, it makes excellent fuel. Some idea of the extent to which the utilization of this peat fuel deposit would conserve other forms of fuel, wood and coal, may be obtained from a recent low estimate of the peat resources of Canada as "equivalent to nearly sixteen million tons of coal."

These are a few of the savings in natural mineral resources which the research man has enabled those operating the various industries to bring about in recent years. Sometimes this saving is due to the utilization of new elements to replace old ones becoming exhausted; often it is brought about by supplying an entirely new compound or mechanism. Of the fifty metallic elements now known there were only seven in commercial use 2000 years ago, viz.: iron, copper, tin, gold, silver, mercury and lead. There

are eight others which were introduced into practical use between the 1st and 19th centuries, viz.: zinc, iridium, platinum, cobalt, nickel, antimony, cadmium and bismuth. That is, the rate of addition has been less than one metal for each two centuries prior to our century. Within our time, that is during the last twenty-five years, there have been about fourteen metals added to commercial use, or a rate more than one hundredfold greater than the previous rate.

A notion of the rapidity with which research has brought about changes in the various electro-chemical and metallurgical industries, is well illustrated by the statement of the president of one of our largest chemical corporations that "progress in chemical industries is taking place so rapidly through the study of new processes, introducing new machinery, new methods, and new materials, that my company has very little in the way of plant today which was in existence ten years ago.

HIGH VOLTAGE ELECTRIFICATION

An interesting further development in electrification of steam railroads is taking place in Montana. The Butte, Anaconda & Pacific Railway extending from Butte to Anaconda a distance of twenty-six miles, with a branch 8½ miles long to Stuart and one 4½ miles long to Butte Hill, is to be electrified. The Butte Hill branch is to be used for freight only and will continue to use steam for the present. The notable feature is the use of 2400-volt direct current locomotives. There are some direct current installations in Europe using 2400 volts or higher, and as high as 1500 volts is in use in this country, but this installation will be the first of any magnitude to utilize direct current of such high voltage.

Fifteen locomotives which weigh seventy-five tons each are being built to take care of the freight movement between Butte and Anaconda. This traffic consists principally of ore trains. The locomotives are to be double headed, hauling trains weighing 3500 tons (about 60 large ore cars) against a grade of about sixteen feet to the mile. Two additional electric locomotives of the same design as the others, except that they are geared for higher speed, will be used to haul regular passenger trains between the two cities. The railroad now employs twenty-eight steam locomotives, all of which will be replaced by electric locomotives with the exception of five which will be used temporarily on the Butte Hill branch until the whole electrification is completed.

The power will be furnished by the power company to two sub-stations which are located at Butte and Anaconda, respectively. The locomotives will draw their current from an overhead trolley. The advantage of high voltage is shown from the fact that the two sub-stations are located twenty-six miles apart and the amount of feeder wire is very moderate in spite of the size of the trains to be hauled. In ordinary 600-volt direct current trolley car work the proper distance apart of the sub-stations is about eight miles. As each sub-station requires considerable expensive machinery and a man constantly on hand to operate it, it will be seen that a considerable saving is effected by the use of higher voltage and consequently increased distance between sub-stations. L. E. M.

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VOL. II JANUARY, 1912 No. 2

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

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VOL. II MARCH, 1912 No. 4

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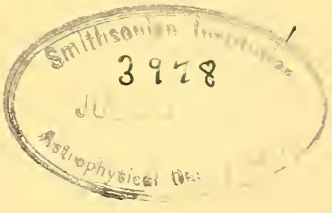

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